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HYDROGEOLOGIC INVESTIGATION

OF

A LAND APPLICATION SITE

PREPARED FOR

UNION OIL COMPANY OF CALIFORNIA

CHICAGO REFINERY

LEMONT, ILLINOIS

BY

CONVERSE/TENECH GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 DESCRIPTION OF FACILITY AND STUDY OBJECTIVES

The Union Oil Company of California, Chicago Refinery, land application site (landfarm) is located in Will County, Illinois, southwest of the city of Lemont and southeast of the main refinery complex (Figure 1). The purpose of the land application area is to dispose of biodegradeable refinery wastes in an environmentally sound manner. The Union Oil Chicago Refinery generates waste streams which include process wastes and combined wastes from its water and waste treatment facilities. Waste sludges have been collected and spread on the site since 1973. The land application area contains a drying bed (used to dewater the sludge material to the point where it can be spread on the land disposal area) and the land treatment/soil incorporation area (Figure 2).

The objective of this study was to provide the supportive hydrogeologic data required in Part III of the Illinois Environmental Protection Agency's Application for Permit to Develop and/or Operate a Solid Waste Management Site. This information was obtained principally by a subsurface drilling and sampling program conducted during February and April 1981 and included the installation of five groundwater monitoring wells in the land application site. A related objective was to develop an appropriate monitoring program and schedule which could be incorporated by Union Oil in the permit application operating plan (Part V of Illinois Environmental Protection Agency's Application for Permit to Develope and/or Operate a Solid Waste Management Site).

2.0 INVESTIGATIVE METHODOLOGY

2.1 Introduction

Prior to the implementation of field activities, existing reports and data pertinent to the land application site were acquired, reviewed, and evaluated by Converse/TenEch. Various agencies were contacted to obtain specific data, including the Illinois Environmental Protection Agency; Illinois State Geological Survey; Illinois State Water Survey; USDA Soil Conservation Service; U.S. Environmental Protection Agency; U. S. Geological Survey; and Will County Mapping and Platting Department.

Process description information and available site maps were provided by Union Oil. Laboratory analyses were conducted to determine physical and chemical properties of earth materials sampled during the drilling program. Field and laboratory data were reduced and analyzed in the office, and this report was prepared.

2.2 Site Reconnaissance and Inspection

The 29.3-acre land treatment site was visited by Dr. Todd Gates and Mr. Glenn Wittman from Converse/TenEch on February 9, 1981. Accompanying them was Mr. Leo Erchull from Union Oil. The site was inspected and preliminary locations of five investigative borings/monitoring wells were noted and discussed, as well as the location of existing monitoring well MW-4 which was installed in 1979 (Dames and Moore, 1979). Existing and future disposal areas, waste boundaries, grading plans, and local hydrogeologic conditions were also reviewed in the field. The above information provided the basis for determining the final locations of the borings/monitoring wells. Monitoring well MW-1 was intended to be a hydraulically upgradient background well; MW-2, MW-3, and MW-4 were to monitor groundwater conditions within and directly adjacent to the waste management area; and MW-5 and MW-6 were intended as hydaulic downgradient perimeter wells.

2.3 Investigative Borings and Monitoring Wells

Five, 3-inch diameter subsurface borings ranging in depth from 88.0 to 116.5 feet were drilled, sampled, and logged during February and April 1981. Immediately following the completion of sampling and logging, each boring was reamed to an 8-inch diameter for the purpose of installing a monitoring well. The boring locations are shown on Figure 2. All borings were drilled to bedrock using direct circulation rotary drilling methods. Water for drilling was obtained from the Union Oil potable water supply and circulated within the boreholes to make natural drilling mud; no additives were used in the drilling fluid. During drilling, split-spoon drive samples were taken at 5-foot intervals for lithologic description and logging by the on-site geologist. Boring logs are presented in Appendix A. The sampling spoon was driven 18 inches or to refusal by a 140-pound weight, free-falling 36 inches. Representative samples from each boring were selected for physical testing and chemical laboratory analyses (Appendices B and C, respectively), sealed in glass jars, and stored in a cool dark place until delivered to the laboratories at the conclusion of the field investigation.

Upon completion of each boring, a 4-inch inside diameter PVC monitoring well was installed for measuring groundwater levels and groundwater quality sampling. All wells were constucted of 10-foot lengths of cemented flush-joint PVC pipe. The bottom 20 feet of pipe was horizontally slotted (0.006-inch slot width). The annular space between the pipe and borehole was filled with medium-to-coarse-grained sand from the bottom of the borehole to several feet above the top of the well screen. After installation of the sand pack, each well was backwashed using the potable water supply. A 3-foot seal of bentonite pellets was installed on top of the sand pack and the hole was then backfilled with clay to 3 feet below ground surface. Finally, a cement seal was poured to the surface.

Water levels in the wells were allowed to stabilize, after which static water level depths from the tops of the casings were measured to the nearest hundredth of a foot with a "Soil Test" electric water level indicator. The elevations of the tops of the well casings were surveyed to the nearest hundredth of a foot to enable level depths to be converted to elevations. Following measurement of the static water level, each well was manually bailed to develop the well by removing at least three times the volume of water contained within the well casing.

Boring logs and well construction details are included in this report as Appendix A. Table 1 presents static water level and elevation data.

2.4 Field Permeability Test

A falling-head permeability test was performed in MW-1 to determine the average horizontal permeability (hydraulic conductivity) of the earth materials in the vicinity of the well screen. As the log of this well indicates (Appendix A), the screened materials are predominantly silty sand and clayey silt represented by the symbol "ML" (Unified Soil Classification System); the USDA classification of these materials is silty loam (Appendix D). The test was conducted after backwashing the well and consisted essentially of measuring the decline of the water level in the well over a period of several hours. The test data and permeability calculation are presented in Appendix E.

TABLE 1

STATIC WATER LEVELS AND ELEVATIONS

Well	Top-of-Casing Elevation	Ground Surface Elevation	Static Water Level Depth Below Top of Casing(ft)	Static Water Level Elevation
MW-1	717.85	715.0	83.50	634.35
MW-2	721.93	719.0	97.33	624.60
MW-3	706.33	704.0	80.28	626.05
MW-4	694.43	692.8	71.42	623.01
MW-5	685.44	683.2	64.30	621.14
MW-6	698.15	696.8	75.00	623.15

Note: Elevations are feet above mean sea level
Static water depths measured April 25, 1981

3.0 REGIONAL SETTING

3.1 Topography and Climate

The Lemont area is located in the Wheaton morainal physiographic subdivision of Illinois. The topography of the area is characterized by hilly terrain, broad parallel morainic ridges, lakes, and swamps. Maximum topographic relief between the land application site and the Des Plaines River to the west is about 150 feet. Maximum relief at the land application site is about 50 feet.

The Chicago Sanitary and Ship Canal and the smaller Illinois and Michigan Canal are east of and parallel to the Des Plaines River. The Illinois and Michigan Canal borders the Union Oil western property line.

The climate in the region is classified as continental with average annual precipitation of about 36 inches (Willman, 1971).

3.2 Regional Geology

The geology of the area is characterized by a broad, gently sloping bedrock surface overlain by thick glacial drift. Bedrock consists of Silurian dolomite that outcrops where the glacial drift has been removed by erosion. In the Lemont area, bedrock outcrops are present along the Des Plaines River. Figure 3 illustrates a representative stratigraphic column (Willman, 1971) of the subsurface geologic conditions.

Glacial drift present within the region was deposited during the Kansan, Illinioan, and Wisconsinan glacial stages. These unconsolidated materials consist of mixtures of till, sand, gravel, silt, clay, peat, and loess deposited by glacial ice, water, and wind. The characteristics of glacial drift are highly variable depending on the depositional environment. In the study region, their thickness may approach 350 feet (Willman, 1971).

3.3 Regional Hydrology

The Lemont area is regionally drained by the generally southward-flowing Illinois and Michigan Canal which parallels the larger Chicago Sanitary and Ship Canal and the Des Plaines River to the west (Figure 1). Surface runoff is discharged to the canal by numerous intermittent streams. Runoff rates and volumes were not calculated, but the hilly topography and published soils information indicate that surface runoff is moderately rapid overall.

Groundwater, within the region, is available from four major aquifer systems:

1. sand and gravel deposits in Pleistocene glacial drift,
2. shallow dolomite formations mainly of Silurian age,
3. the Cambrian-Ordovician Aquifer of which the Ironton-Galesville (Cambrian) and Glenwood-St. Peter (Ordovician) sandstones are the most productive, and
4. the Mt. Simon Aquifer (lower Ordovician) which consists of sandstones of the Mt. Simon and lower Eau Claire Formations.

Shallow sand and gravel aquifers underlie approximately 50 percent of the region. Yields from wells in these materials are highly variable, ranging from less than 25 to more than 1,000 gallons per minute (gpm). These aquifers are recharged by local precipitation (Schicht, 1976).

Shallow dolomite aquifers are generally recharged by vertical leakage from the overlying glacial drift. Well yields from these aquifers are inconsistent, although yields exceeding 500 gpm occur in many areas (Schicht, 1976).

The Cambrian-Ordovician Aquifer is situated approximately 500 feet below the ground surface and has an average thickness of 1,000 feet. Yields from this aquifer generally exceed 700 gpm. The recharge area for this deep aquifer is the western portion of the region, although some vertical leakage from overlying and underlying confining beds is reported to occur (Schicht, 1976).

Beneath the Cambrian-Ordovician Aquifer lies the Mt. Simon Aquifer which is recharged in southeastern Wisconsin. High-capacity wells penetrate the upper 200 to 300 feet of this 2,000-foot-thick aquifer. Within the Mt. Simon sandstone, water quality problems may occur with increasing depth of penetration (Schicht, 1976).

4.0 Site Conditions

4.1 Description of Land Application Area

The existing land application area consists of one sludge drying bed, and three active sludge landspreading/soil incorporation disposal (land application) areas immediately to the west and north of the drying bed (Figure 2). The general direction of runoff flow from the waste management area is north to an intermittent stream which flows from the east through the site past monitoring wells MW-6 and MW-5 (Figure 2). This stream, which occasionally receives supernetent liquid from the sludge drying bed, then flows west to the storm water basin, and then to Union's wastewater plant where runoff is treated prior to discharge.

One additional land application area on the site can be used for potential future landspreading activities (Figure 2). Monitoring well MW-1, the background well, is located along the easternmost boundary of this future land disposal area.

4.2 Site Hydrogeology and Subsurface Conditions

The site hydrogeology was defined by the boring logs and groundwater information obtained during and after drilling of the borings and installation of monitoring wells. The boring logs (Appendix A) indicate that 13 or 14 distinguishable lithologic layers comprise the approximately 100-foot thickness glacial drift blanketing dolomite bedrock. Several of these layers are distinguished, however, on the basis of color and/or small differences in proportions of clay, silt, and/or sand. The laboratory grain-size determinations (Appendix B) and closer examination of the logs, reveal that there are seven major lithologic units comprising the unconsolidated material overlying bedrock. These units are indicated in the three generalized geologic cross-sections shown on Figure 4. Cross-section A-A' extends west to east through wells MW-4, MW-3, MW-2, and MW-1. Cross-section B-B' extends northwest to southeast from MW-5 to MW-3, and cross-section C-C' extends northwest to southeast from MW-6 to MW-2.

Cross-section A-A' reveals that the western sludge disposal area (between MW-4 and MW-3) is immediately underlain by 15 to 20 feet of silty clay. Beneath this material is about 15 feet of clay which grades into silty clay towards MW-2. The lower 55 feet or so of unconsolidated material above bedrock is sandier but still has a significant silt/clay content.

The existing sludge drying bed is situated Just west of MW-2. Thirty-five to 50 feet of silty clay and clay underlies the drying bed. A 9-foot thick layer of clayey sand and clean sand was logged in borehole MW-2 from a depth of 18 to 27 feet, but this unit was not logged in any of the other boreholes. It is, therefore, thought to be an isolated lens of sand with limited lateral distribution. The material beneath the sludge bed, below a depth of about 50 feet, is essentially the same sandy material present at depth beneath the western sludge disposal area and noted in the preceeding paragraphs. Cross-section A-A' indicates that the upper 50 feet of earth materials to the east of MW-2 towards MW-1 are slightly siltier and the clay and underlying silty sand unit present in MW-4 and MW-3 are absent. Cross-sections B-B' and C-C' are included on Figure 4 for the sake of completeness and indicate that similar lithologic sequences, as described for cross- section A-A', are typical throughout the land application area.

As previously discussed in Section 3.2, Regional Geology, the unconsolidated materials beneath the land application area are glacial drift deposited when the glaciers melted and receded. It should be noted that slight amounts (0 to 20% by weight) of fine gravel to small cobble-size rocks were present in most of the clayey and silty material. This is noted in the boring log descriptions and USDA textural classifications but not in the generalized cross-sections. As indicated previously, the cross-sections, while accurate and representative, are generalized representations of the subsurface materials and were drawn based on samples collected at five-foot intervals. They are considered the primary earth materials which determine the permeability beneath the land application area. None of the five investigative borings drilled during this study encountered shallow or perched water table conditions, (i.e. none of the shallower sampled materials was saturated). Groundwater conditions were not encountered at any depths shallower than approximately ten feet above bedrock. This may be explained by the low permeabilities and substantial thickness of the shallower materials, (i.e. clays, silty clays, and clayey silts). For laboratory samples, typical permeabilities of these materials range between 10^{-6} and 10^{-8} cm/sec (EPA, 1978).

An in-situ filling head permeability field test was performed at MW-1. The results of this test (see Appendix E), indicated that the average horizontal permeability of the materials surrounding the well screen is on the order of 10^{-5} cm/sec which is relatively low. The vertical permeabilities are likely to be several times to an order of magnitude lower than the horizontal permeabilities. The conditions at MW-1 are believed to be characteristic of the glacial clayey deposits occurring throughout the land application area.

The static water levels shown in Table 1 and on Figure 5 are the depths/elevations to which the water level rose in the monitoring well after the water-bearing layer was penetrated. This water level rise is indicative of artesian or confined aquifer conditions. Additionally, the fact that groundwater was not encountered until within ten feet of the bedrock contact supports the lack of significant direct hydraulic continuity between the land application areas and the groundwater flow system.

The rate of water movement within the saturated layer overlying bedrocks can be calculated by multiplying the hydraulic gradient between any two wells in the same flow path by the hydraulic conductivity of the earth materials. Figure 5 reveals that the maximum hydraulic gradient recorded beneath the land application site is 0.015 between the 634 and 625 foot contours. Using the horizontal permeability measured at MW-1, the rate of groundwater movement from MW-1, the background well, toward MW-2 is 3.56×10^{-5} cm/sec x 0.015 = 5×10^{-7} cm/sec or about 1.5×10^{-3} ft/day (ft^3/ft^2/day). It is interesting to note and not unusual, that the general groundwater flow direction tends to mirror with subdued relief of the surficial topography. Based on the investigative borings, a comparison of the bedrock contours (Figure 6) with the groundwater flow directions shown in Figure 5 shows cross cutting relationships indirective of limited bedrock control of groundwater flow direction. It is, therefore, concluded that groundwater flow directions in the upper portion of the saturated zone are predominately controlled by the surficial morphology. This would imply that the overall flow direction of the near surface groundwater environment is most probably, down hill towards the system of river and canals located topographically below the top of the water table in the land application area.

4.3 Laboratory Chemical Analysis - Soils

Appendic C presents the soils analysis report and soil fertility recommendations prepared by A & L Great Lakes Agricultural Laboratories, Inc. of Fort Wayne, Indiana. A summary of the cation exchange capacity (C.E.C.) and pH of soils at various depths is presented in Table 2. Inspection of Table 2 shows that from the ground surface to a depth of approximately 45-60 feet the cation exchange capacity for soils underlying the land application area are moderate to high. Considering the predominance of silty clay, clayey silt and sand, silty sand and other fine grained soils, and their thicknesses shown in the generalized cross-section (Figure 4), these results are considered generally typical for the types of material sampled. The pH values for samples below five feet are in an excellent range (7.9-8.4) and compatible with sludge disposal by land application. Surficial pH values (5.7-8.2) are generally acceptable for land application, however, moderate supplemental liming is suggested to maximize the cation exchange capacity.

Soil nutrients (eg. nitrogen-phosphate-potash) for all samples analyzed (see Appendix C) are, in general, very low to low. In order to maximize the rate of biodegradation, particularly in the near surface soil environment, the addition of supplemental nitrogen, phosphate and potash is recommended.

4.4 Groundwater Quality

The results of the groundwater quality analysis performed by Union Oil are presented in Appendix F and summerized in Table 3. An inspection of Table 3 shows that the USEPA Interim Primary Drinking Water Standard for lead is slightly exceeded in MW-1 and MW-6. Similarly, the Proposed Secondary Drinking Water Standard is slightly exceeded for iron in the control blank (Union Oil Potable Water), MW-1, MW-2, MW-4, MW-5, and MW-6; for manganese in MW-1, MW-2, MW-3, MW-5 and MW-6; for TDS in MW-1, MW-2, MW-3 and MW-6. As MW-1, the background monitoring well which is located hydraulically up-gradient approximately 1/5 mile from the active land application area is consistantly above the drinking water standard for the above parameters (lead, iron, manganese and TDS); it is likely that the observed groundwater quality reflect ambient, although possibly not natural conditions. It is interesting to note that the control bank (Union Oils potable water) and groundwater quality results are in general, quite similar. This occurrence tends to support the possibility that the observed elevated values are typical of the surrounding regional groundwater quality.

TABLE 2

Cation Exchange Capacity

and pH of Soil Samples

	Monitoring Well No.				
	1	2	3	5	6
SAMPLE DEPTHS					
Surface					
C.E.C.*	13.6	9.9	13.2	13.6	5.5
pH	6.4	6.7	8.2	7.3	5.7
5' - 10'					
C.E.C.*	13.0	13.3	13.5	12.0	15.6
pH	8.2	8.2	8.4	8.4	8.2
15' - 25'					
C.E.C.*	12.1	8.3	13.2	11.3	10.5
pH	8.2	8.1	8.1	7.9	8.2
45' - 60'					
C.E.C.*	11.9	7.3	11.1	9.8	9.1
pH	8.0	8.4	8.2	8.0	8.3

Note: * C.E.C., miliequivalents per 100 grams of soil (meg/100g)

TABLE 3

WELL WATER ANALYSIS[a]

	Reference[1] Blank	Control[2] Blank	Well 1	Well 2	We
Alkalinity	nd(<1)	266	398	298	343
Aluminum	0.07	0.05	0.06	0.2	0.
Arsenic	0.004	0.009	0.010	0.009	0.
Barium	nd(<0.02)	0.05	0.11	0.04	0.
Bicarbonate	nd(<1)	325	485	364	419
Boron	nd(<0.1)	0.6	0.4	0.6	0.6
Bromide	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)
Cadmium	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.
Calcium	0.06	62	79	49	74
Carbonate	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)
Chloride	nd(<1)	26	23	28	30
Chromium (total)	0.006	0.005	0.004	0.004	0.0
Chromium (VI)	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.0
Chromium (III)	0.006	0.005	0.004	0.004	0.0
Copper	0.02	nd(<0.02)	nd(<0.02)	nd(<0.02)	0.0
COD	nd(<0.5)	nd(<1)	385	73	nd(<0.5
Cyanide	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.0
Flouride	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2
Hardness	nd(<4)	233	425	507	342
Iron	0.2	0.4(4)	0.4(4)	0.5(4)	0.3
Lead	nd(<0.05)	nd(<0.05)	0.1(4)	nd(<0.05)	nd(<0.
Magnesium	nd(<0.5)	18	55	93	38
Manganese	0.01	0.02	0.20(4)	0.09(4)	0.0
Mercury	nd(<0.0005)	nd(<0.0005)	0.0008	0.0008	nd(<0.
Nickel	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.0
Nitrate	nd(<1)	3	nd(<1)	nd(<1)	nd(<1)
Phenols	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.0
Phosphate	nd(<1)	1	4	5	5
Potassium	nd(<0.01)	15	7.8	11	13
Selenium	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5
Silver	nd(<0.02)	nd(<0.02)	n[illegible]2)	nd(<0.02)	nd(<0.
Sodium	0.1	72		115	72
Specific Conductance	0.77 uS/cm	709 uS/cm	1095 uS/cm	801 uS/cm	810
Sulfate	nd(<1)	86	233	106	116
TDS	2	486	761(4)	546(4)	567(
TOC	4.0	2.0	11.0	8.0	18.
TOX (as Cl)	0.005	0.025	0.060	0.54	0.
Zinc	0.03	1.9	0.03	0.1	0.
Oil & Grease	<0.1	0.8	1.4	1.1	1.
pH	7.0	6.9	6.9	6.5	6.

Notes:

a All results are reported in mg/l except where otherwise indicated.
nd None detected. If present at all, the concentration is less than the indicated amount.
1 Deionized water from laboratory at Chicago Refinery.
2 Chicago Refinery potable water from fire station.
3 USEPA Primary or Secondary Drinking Water Standard.
4 Exceeds Primary or Secondary Drinking Water Standard.

…ALYSIS[a]

	We…	Well 4	Well 5	Well 6	STD[3]
	343	643	430	334	---
	0.08	nd(<0.02)	0.05	0.06	---
	0.015	0.033	0.010	0.009	0.05
	0.05	0.04	0.09	0.09	1.0
	419	784	524	407	---
	0.6	0.1	0.2	0.5	---
	nd(<1)	nd(<1)	nd(<1)	nd(<1)	---
)	nd(<0.[illegible]	[illegible](<0.01)	nd(<0.01)	nd(<0.01)	0.01
	74	133	99	64	---
	nd(<1)	nd(<1)	nd(<1)	nd(<1)	---
	30	3	9	28	250
4	0.004	0.004	0.005	0.004	---
2)	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.002)	0.05
4	0.004	0.004	0.005	0.004	---
)	0.02	nd(<0.02)	nd(<0.02)	nd(<0.02)	1.0
	nd(<0.5)	nd(<0.5)	nd(<0.5)	22	---
)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	---
	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2)	1.4-2.4
	342	732	488	280	---
4)	0.3	0.4[4]	0.4[4]	0.4[4]	0.3
)	nd(<0.05)	nd(<0.05)	nd(<0.05)	0.07[4]	0.05
	38	97	58	29	---
4)	0.06[4]	0.05	0.39[4]	0.10[4]	0.05
08	nd(<0.0005)	nd(<0.0005)	nd(<0.0005)	nd(<0.0005)	0.002
)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	---
	nd(<1)	nd(<1)	nd(<1)	nd(<1)	10
3)	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.003)	---
	5	nd(<1)	nd(<1)	4	---
	13	3.1	10	11	---
	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5)	0.01
)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	0.05
	72	16	22	84	---
/cm	810 uS/cm	1250 uS/cm	960 uS/cm	810 uS/cm	---
	116	134	122	96	250
	567[4]	368	497	540[4]	500
	18.5	11.0	15.0	4.0	---
	0.020	0.015	0.005	0.030	---
	0.06	0.04	0.03	0.03	5
	1.5	0.7	3.6	1.2	---
	6.7	6.8	7.3	7.0	6.5-8.5

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the cumulative thickness of low permeability materials, consisting predominately of silty clay, clayey silt, silty sand, and clayey silt and sand, which vary in thickness from approximately 35 feet to a thickness slightly greater than 60 feet, and the depth to the top of the water table, which varies from approximately 60-100 feet below the land surface, it is concluded that the subsurface soil and hydrologic conditions are favorably for disposal of refinery sludges by land application. Additionally, except for the surficial soils which require soil amendments as recommended below, the general soil chemistry including pH and cation exchange capacity appear favorable for refinery sludge disposal by land application. The pH values for fifteen samples, ranging in depth from 5-60 feet below the ground surface, all exceeded 6.5, varying from 7.9 to 8.4 feet. Similarily, the cation exchange capacity in meg/100g of soil for these samples varied between 7.3-15.6, averaging 11.5 for the fifteen samples analyzed.

Assuming appropiate operating conditions, including sludge application rates, maintenance of aerobic conditions and exclusion of incompatible waste from the land application area; and the implementation of the recommendations below, it is concluded that the subsurface conditions are favorable for the disposal of refinery sludges by land application. The recommendations presented below are directed at two objectives.

First, is to improve the surficial soil chemistry to promote the rate of biodegradation and cation exchange capacity; and, second, is to recommend an appropiate groundwater, soil and pore water monitoring program which when implemented will function to provide the necessary assurance of containment within the confines of the land application area.

5.2 Recommendations

5.2.1 Surficial Soil Chemistry Improvements

Refinery sludge disposal by land application relies principally on rapid biodegradation and contaminant retention within the zone of surficial soils. The analytical results of this study indicate surficial soil chemistry at the Chicago Refinery, that range for good to unacceptable (see Table 2). It should be noted, however, that the fact that unacceptable surficial soil chemistries exist at some locations in the land applicaiton area does not imply that land treatment is an unacceptable disposal method. Rather, it simply requires that supplemental soil nutrients and amendments be added, prior to the sludge application. In practice, surficial soil conditioning is a continuing requirement at most land treatment facility. Conceptually and in general practice, it is not significantly different than agronomic soil treatment employed for optomizing agricultural productivity.

Therefore, in order to adjust the surficial soil chemistry, additions of the following soil supplements is recommended.

Lime	1 ton/acre
Nitrogen*	150 lbs./acre
Phosphate*	75 lbs./acre
Potash*	75 lbs./acre

* Note: Pounds per acre are presented in terms of available nutrient. Application rates for commercial fertilizers will, therefore, have to be adjusted accordingly.

Fertilization and liming should occur prior to sludge application and be continued on an as needed basis as discussed in Section 5.2.3.1.

5.2.2 Groundwater Monitoring

It is believed that the groundwater monitoring network (MW-1 through MW-6), meets or exceeds the monitoring well requirements of United States and State of Illinois Environmental Protection Agencies. It is, therefore, recommended that supplemental installation of monitoring wells is not required.

Routine groundwater monitoring including, sample collection, sample preservation and shipment, analytical proceedures, and chain of custody control, should be performed in accordance with methods and procedures outlined in the following documents or equivalent alternatives.

- Handbook for Analytical Quality Control in Water and Wastewater Laboratories, EPA-600/4-79-019, March 1979
- Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1979
- Procedures Manuel for Groundwater Monitoring at Solid Waste Disposal Facilities, EPA-SW-611, December 1980

The recommended chemical analysis are presented in Table 4. Sampling and analysis should be performed quarterly for the first year of monitoring.

TABLE 4

Recommended Groundwater Analysis

(1) Parameters characterizing the suitability of the groundwater as a drinking water supply (Interim Primary Drinking Water Standards):

Arsenic	Endrin(1)
Barium	Lindane(1)
Cadmium	Methoxychlor(1)
Chromium - (VI)	Toxaphene(1)
Flouride	2, 4-D(1)
Lead	2, 4, 5-TP Silvex(1)
Mercury	Radium(1)
Nitrate	Gross Alpha(1)
Selenium	Gross Bata(1)
Silver	Coliform Bacteria(1)

(2) Parameters establishing groundwater quality:

Chloride	Phenols
Iron	Sodium
Manganese	Sulfate

(3) Parameters used as indicators of groundwater contamination:

pH	Total Organic Carbon
Specific Conductance	Total Organic Halogen

(4) Analysis required by Illinois EPA:

Alkalinity, as $CaCO_3$	Iron(2)
Aluminum	Lead(2)
Arsenic(2)	Magnesium
Bicarbonate (HCO_3)	Manganese(2)
Boron	Mercury(2)
Bromides (B_r)	Nickel
Cadmium(2)	Nitrate(2)
Calcium	pH
Carbonate (CO_3)	Phenol
Chloride(2)	Phosphate
Chromium - Trivalent (Cr^{+3})	Potassium
Hexavalent (Cr^{+6})(2)	Sodium(2)
COD	Specific Conductance(2)
Copper	Sulfate(2)
Cyanide	Total Dissolved Solids
Floride(2)	Zinc
Hardness, as $CaCO_3$	Oil and Grease

TABLE 4 (Continued)

Notes

(1) Specified in 40 CFR Part 265.92 (b), (1), however variance may be granted based on Union Oil Companies ability to demonstrate absense of these parameters from land disposed refinery sludges.

(2) Analysis is contained in U.S.E.P.A. requirements identified in Items 1, 2 or 3 above and need not be duplicated. Duplication is presented herein to present the State of Illinois list of required analysis in its entirety.

Following the first year of groundwater monitoring (ie. four quarterly samples at each monitoring well location), the sampling and analysis schedule presented below is required.

(1) Annual analysis at all monitoring wells for the following parameters:

Iron
Magnanese
Phenols
Sodium
Sulfate

(2) Semi-annual analysis at all monitoring wells for the following parameters:

pH
Total Organic Carbon (TOC)
Total Organic Halogen (TOH)
Specific conductance

(3) Quarterly analysis at all monitoring wells for the following parameters:

Chloride
Total Dissolved Solids
or Conductivity

It is likely, although not clearily specified, that a complete schedule of analysis similar to that shown in Table 4 will be required on a periodic (annual or biannual) basis following the first year of monitoring. It is recommended, based on the parameters listed in Table 3 and the results of first years quarterly monitoring result, that an abbreviated yet complete schedule of analysis, similar to Table 3, be developed. Additionally, a water level measurement of the groundwater surface at each monitoring well must be determined each time a sample is obtained.

5.2.3 Soil and Pore Water Monitoring

Within the zone of aeration overlying the groundwater table, soil and pore water monitoring should be implemented to detect the potential migration of leachate contaminants and provide general background information. These monitoring activities should be performed in both a control area and the active land application area. Treatment (ie. soil amendments, nutrients, vegetation cover, etc.) of the control area should be the same as that in the active land application area. The control area should, however, not have been used in past, present, or future for sludge and/or waste disposal.

The number and location of sampling points is not fixed, but rather a function of the affected area over which active land application is occurring. This sampling protocol is applicable to both soil and pore water sampling discussed in Sections 5.2.3.1 and 5.2.3.2, respectively.

It is, therefore, recommended that the number of sampling locations should equal one per acre for the active land application area, up to a maximum of three randomly placed, well spaced, sample locations in active land application areas larger than three acres. An additional baseline sampling location should be located in the control area. It should be noted that successive sampling within the same land application area need not duplicate previous sample locations. It is preferable, in fact, that sample locations be varied with time in order to accumulate data that characterizes the entire surface of the active disposal area.

The recommended sampling methodology consists of the following procedures.

5.2.3.1 Soil Samples

Hydraulic or hand driven soil cores should be collected at each of the selected monitoring locations. At each location, samples should be collected within the zone of sludge incorporation (approximately the surface to a depth of one foot) and below the zone of sludge incorporation (approximately from a depth of two feet to a depth of three feet). The surficial sample (0-1 foot) should be tested for pH and soil nutrients in order to determine the type and application rate of soil amendments which will be applied to the land application area on an as needed basis. Analysis of the deeper (2-3 foot) soil samples will be for constituents identified during waste characterization as specified in 40 CFR Part 265.273 (a) and (b) (discussed below).

5.2.3.2 Pore Water Samples

Pore water samples should be collected from a depth of approximately 4-6 feet below the land surface using vacuum lysimeters. Lysimeters should be placed in the bore hole remaining after soil sampling. In order to install the lysimeter, the soil bore hole will most probably need to be enlarged and deepened utilizing a hand auger. Pore water samples should be taken immediately after sludge application and immediately after the first significant rain fall following sludge application. Pore water samples should be analyzed for constituents identified during waste characterization as specified in 40 CFR Part 265.273 (a) and (b) (discussed below).

5.2.3.3 Chemical Analysis

The required chemical analysis as specified in 40 CFR Part 265.273 (a) and (b) include those constituents that exceed the maximum allowable concentrations determined during EP Toxicity testing of wastes and those constituents which caused the wastes to be listed as hazardous under 40 CFR Part 261.32. It is reported by Union Oil that EP toxicity testing of waste sludges did not exceed the maximum allowable concentrations. Therefore, based on Union Oil's Notification of Hazardous Waste Activities dated July 28, 1980, the analysis indicated for soil and pore water samples would include hexavalent chromium and lead.

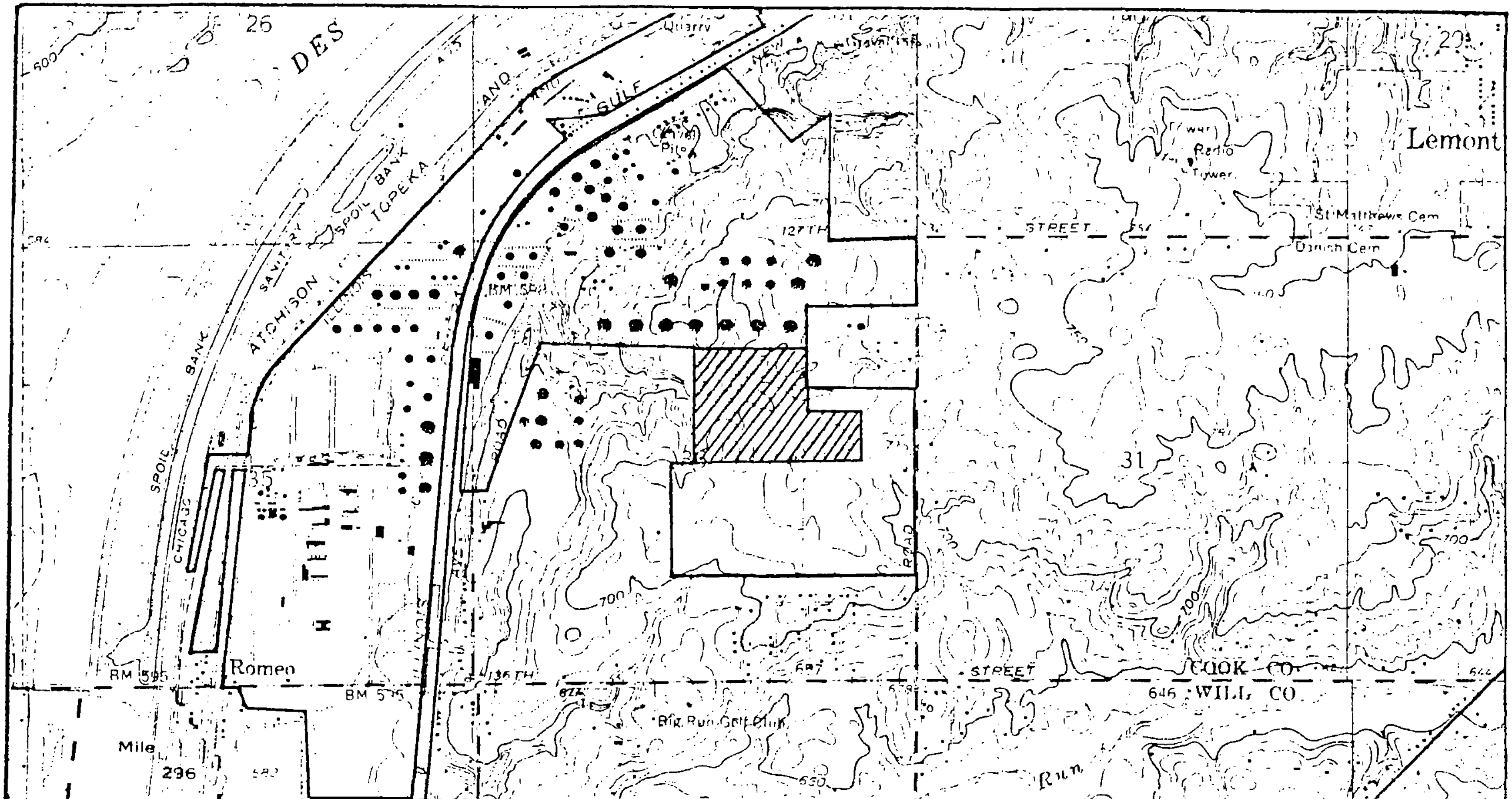
6.0 REFERENCES

Dames and Moore 1979, Technical Evaluation - Existing Landfarming Facility at the Chicago Refinery, For: Union Oil of California, Chicago Refinery, Lemont, Illinois.

Schicht 1976, Water Resources Availability, Quality, and Cost in Northeastern Illinois, Report of Investigation 83 (ISWS/RI-83/76).

U. S. Environmental Protection Agency, October 1978, Process Design Manuel Municipal Sludge Landfills, EPA-625/1-78-010, SW-705.

Willman, H.B., 1971, Summary of the Geology of the Chicago Area, Illinois State Geological Survey Circular 460. Urbana, Illinois.



LEGEND

LAND APPLICATION SITE

UNION OIL PROPERTY BOUNDARY

N

0 2000

SCALE IN FEET

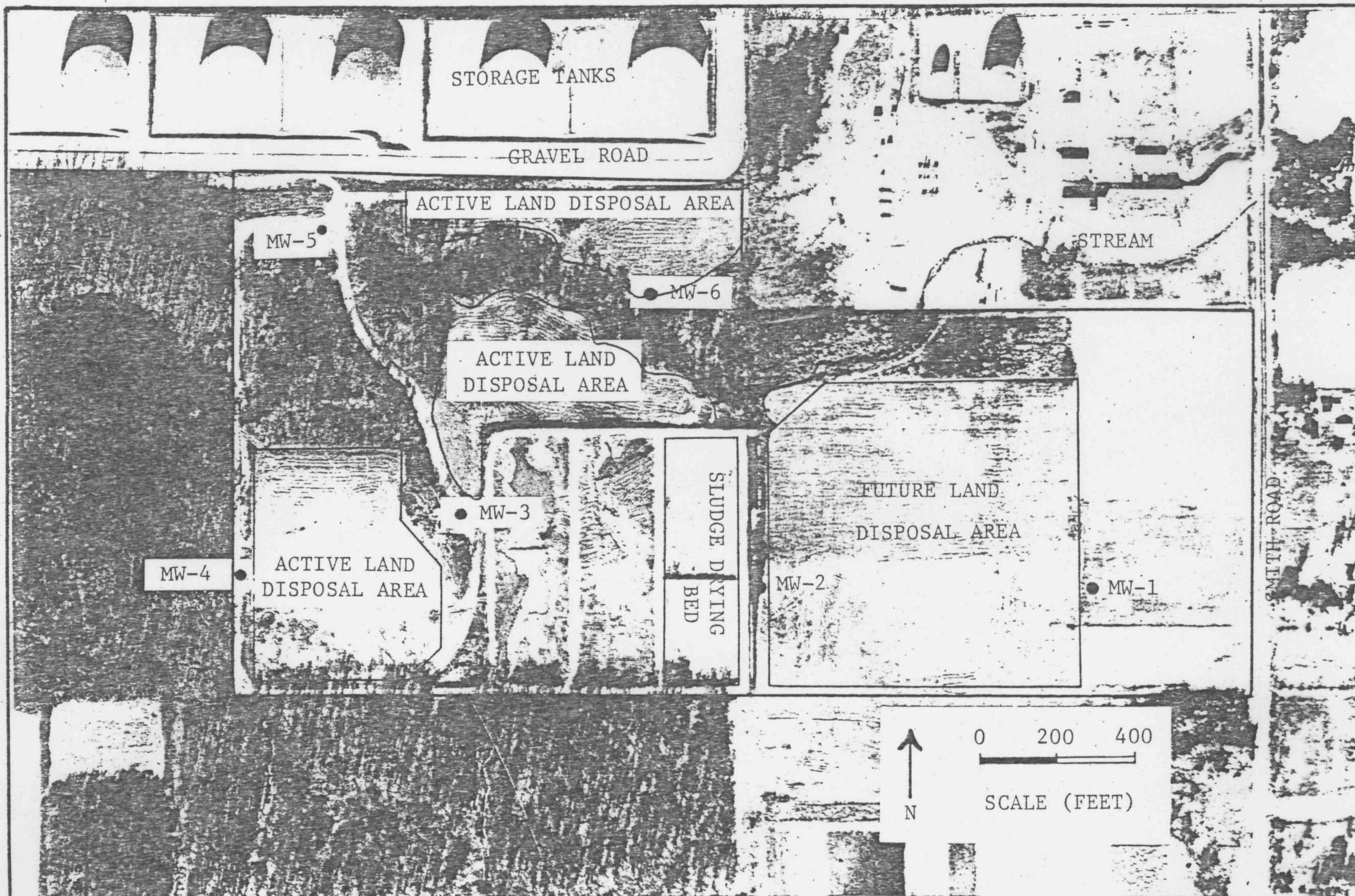
UNION OIL - CHICAGO REFINERY

HYDROGEOLOGIC INVESTIGATION

Converse/TenEch Geotechnical and Environmental Consultants

FIGURE 1

LOCATION MAP OF REFINERY



Converse/TenEch Geotechnical and Environmental Consultants

UNION OIL - CHICAGO REFINERY

HYDROGEOLOGIC INVESTIGATION

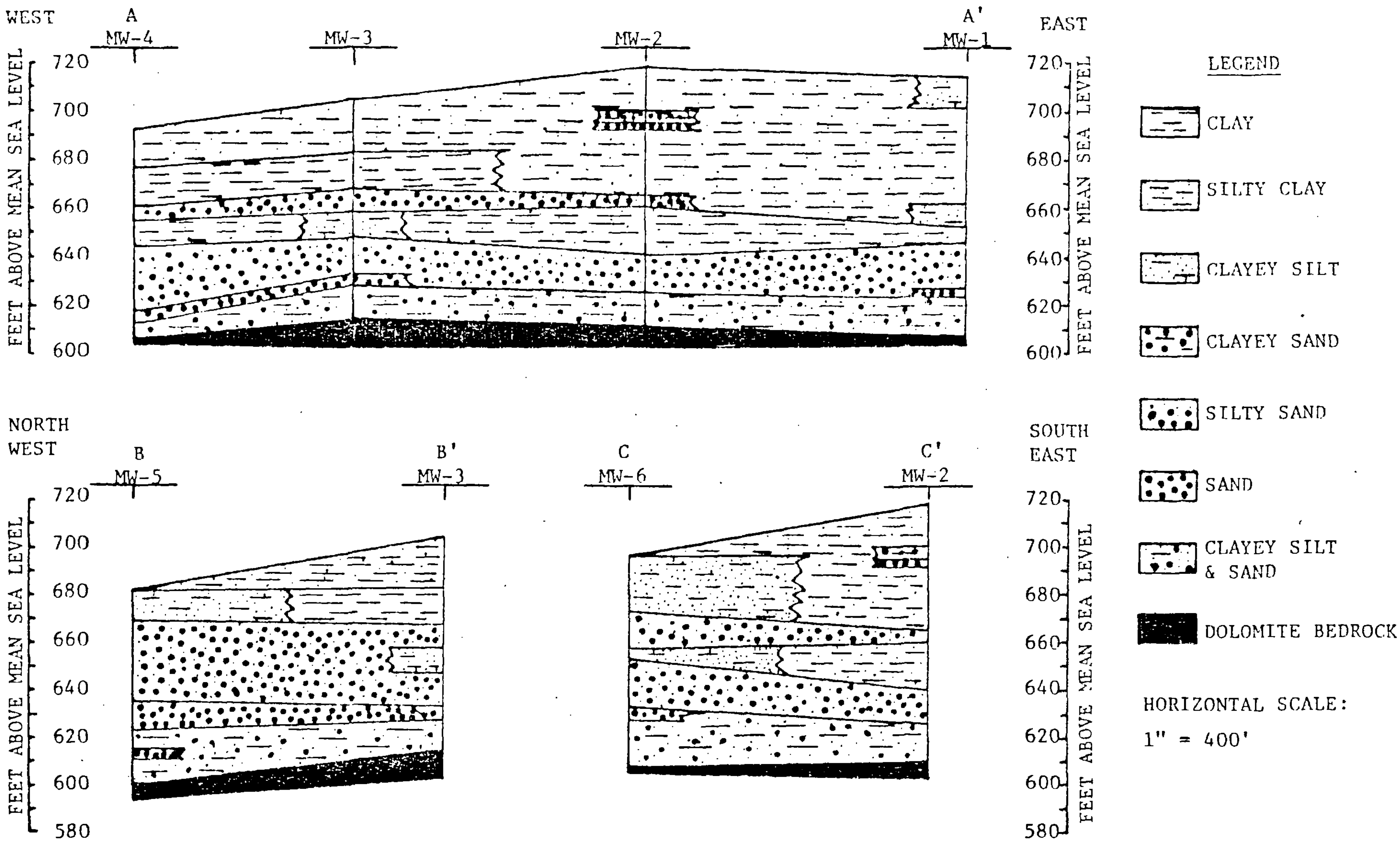
FIGURE 2

SITE MAP OF LAND

Time Stratig: System	Series	Stage	Rock Stratigraphy: Megagroup	Group	Formation	Graphic Column	Thickness (Feet)	Kinds of Rock	
QUAT	PLEIS				(See fig 15)		0-350	Till, sand, gravel, silt, clay, peat, marl, loess	
PENN	DESM			Kewanee	Carbondale		0-125	Shale, sandstone, thin limestone, coal	
					Spoon		50-75	As above, but below No 2 Coal	
MISS	VAL				Burl-Keokuk		0-700	Limestone	Only in Des Plaines Disturbance
	KIND				Hannibal			Shale, siltstone	
DEV	UP				Grassy Creek		0-5	Shale in solution cavities in Silurian	
SILURIAN	NIAGARAN		Hunton		Racine		0-300	Dolomite, pure in reefs; mostly silty, argillaceous, cherty between reefs	
					Waukesha		0-30	Dolomite, even bedded, slightly silty	
					Joliet		40-60	Dolomite, shaly and red at base, white, silty, cherty above pure at top	
	ALEX				Kankakee		20-45	Dolomite, thin beds, green shale partings	
					Edgewood		0-100	Dolomite, cherty, shaly at base where thick	
ORDOVICIAN	CIN	RICH		Maquoketa	Neda		0-15	Oolite and shale red	
					Brainard		0-100	Shale, dolomitic, greenish gray	
					Ft Atkinson		5-50	Dolomite green shale, coarse limestone	
		MAY / ED			Scales		90-120	Shale, dolomitic, gray, brown, black	
	CHAMPLAINIAN	TRENT	Ottawa	Galena	Wise Lake		170-210	Dolomite, buff, pure	
					Dunleith			Dolomite, pure to slightly shaly; locally limestone	
					Guttenberg		0-15	Dolomite, red specks and shale partings	
		BLACKRIVERAN		Platteville	Nachusa		0-50	Dolomite and limestone, pure, massive	
					Grand Detour		20-40	Dolomite and limestone, medium beds	
					Mifflin		20-50	Dolomite and limestone, shaly, thin beds	
					Pecatonica		20-50	Dolomite, pure, thick beds	
				Ancell	Glenwood		0-80	Sandstone and dolomite, silty; green shale	
					St Peter		100-600	Sandstone, medium and fine grained; well rounded grains chert rubble at base	
	CANADIAN		Knox	Prairie du Chien	Shakopee		0-70	Dolomite, sandy; oolitic chert; algal mounds	
					New Richmond		0-35	Sandstone fine to coarse	
					Oneota		190-250	Dolomite, pure, coarse grained; oolitic chert	
					Gunter		0-15	Sandstone, dolomitic	
CAMBRIAN	CROIXAN	TREMP			Eminence		50-150	Dolomite, sandy	
					Potosi		90-220	Dolomite; drusy quartz in vugs	
		FRAN			Franconia		50-200	Sandstone, glauconitic; dolomite; shale	
					Ironton		80-130	Sandstone, partly dolomitic, medium grained	
		DRESBACHIAN			Galesville		10-400	Sandstone, fine grained	
					Eau Claire		370-570	Siltstone, dolomite, sandstone and shale, glauconitic	
			Potsdam		Mt Simon		1200-2900	Sandstone, fine to coarse; quartz pebbles in some beds	
PRE-CAM								Granite	

FIGURE 3

GENERALIZED STRATIGRAPHIC COLUMN FOR CHICAGO, ILLINOIS AREA



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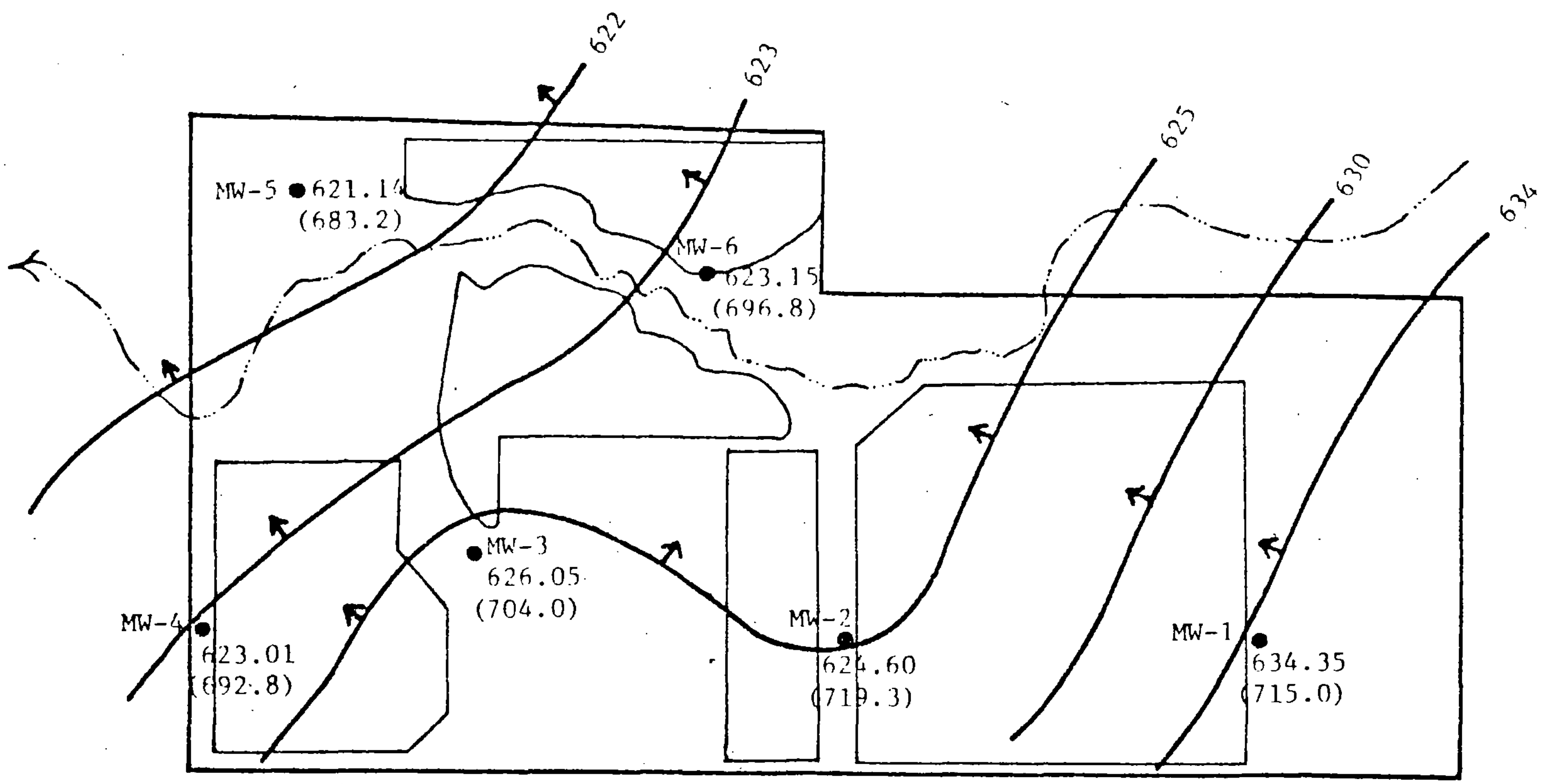
UNION OIL - CHICAGO REFINERY
HYDROGEOLOGIC INVESTIGATION
FIGURE 4

GENERALIZED CROSS-SECTIONS THROUGH LAND APPLICATION AREA



LEGEND

MW-1 ● 634.35 MONITORING WELL & STATIC WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL (4/25/81)

634 LINE OF EQUAL ELEVATION AND DIRECTION OF GROUNDWATER FLOW

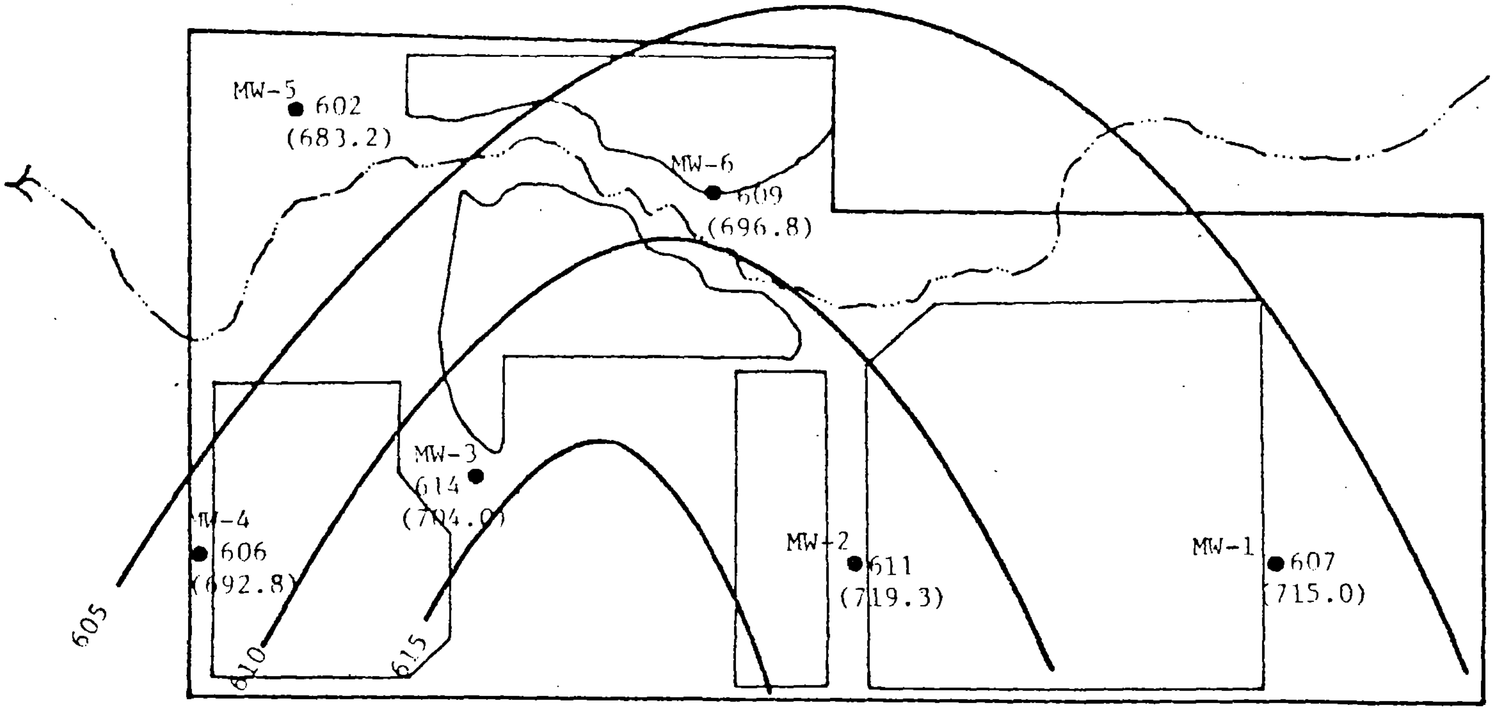
(715.0) GROUND SURFACE ELEVATION

N

0 400
SCALE IN FEET

Converse/TenEch Geotechnical and Environmental Consultants

UNION OIL - CHICAGO REFINERY
HYDROGEOLOGIC INVESTIGATION
FIGURE 5
STATIC WATER LEVEL CONTOUR MAP
OF LAND APPLICATION AREA



LEGEND

MW-1 ● 607 MONITORING WELL & APPROXIMATE BEDROCK ELEVATION IN FEET ABOVE MEAN SEA LEVEL

605 ~ LINE OF EQUAL ELEVATION

(715.0) GROUND SURFACE ELEVATION

N

0 400
SCALE IN FEET

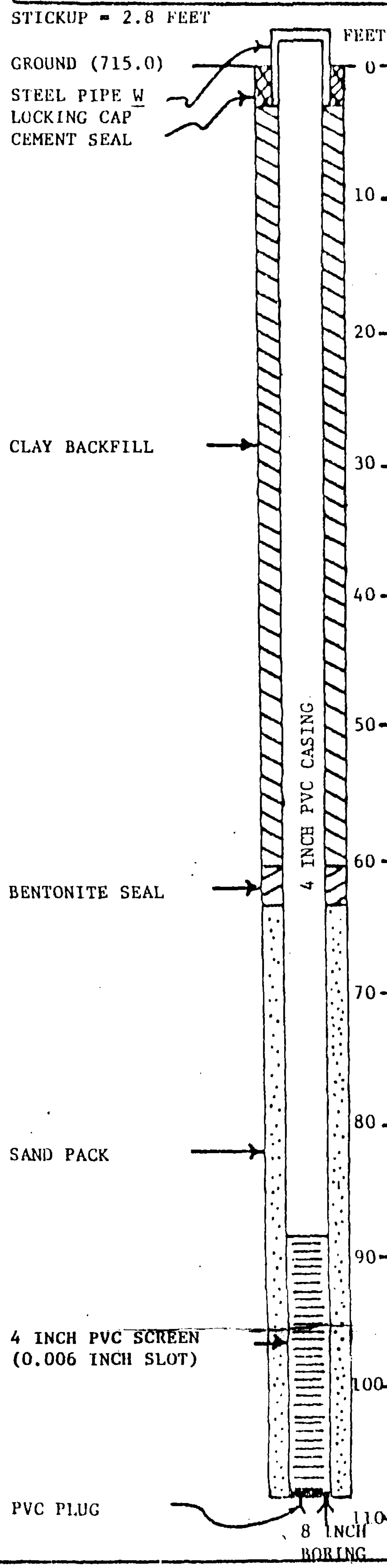
Converse/TenEch Geotechnical and Environmental Consultants

UNION OIL - CHICAGO REFINERY
HYDROGEOLOGIC INVESTIGATION
FIGURE 6
BEDROCK SURFACE CONTOUR MAP
OF LAND APPLICATION AREA

APPENDIX A

BORING LOGS AND WELL DETAILS

WELL CONSTRUCTION DETAILS	GENERALIZED LITHOLOGIC DESCRIPTION

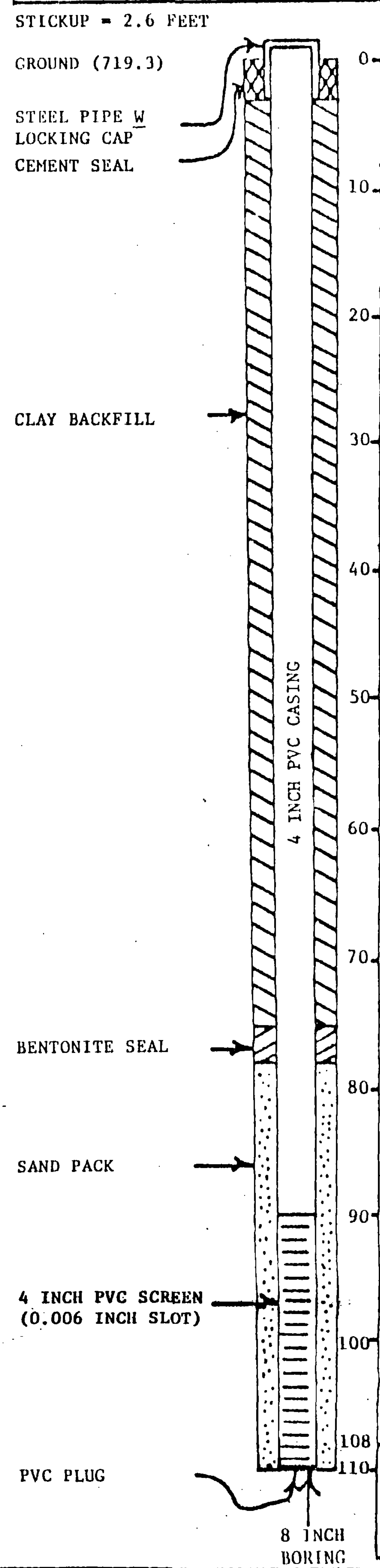


GENERALIZED LITHOLOGIC DESCRIPTION
BROWN MOTTLED TAN AND GREY CLAYEY SILT WITH TRACE FINE GRAVEL AND ORGANIC MATERIAL
TAN MOTTLED GREY CLAYEY SILT WITH LITTLE FINE TO MEDIUM GRAVEL
GREY SILTY CLAY WITH TRACE FINE GRAVEL
GREYISH BROWN SILTY CLAY
GREYISH TAN CLAYEY SILT WITH SOME VERY COARSE SAND AND FINE GRAVEL
BROWNISH GREY CLAYEY SILT WITH LITTLE FINE GRAVEL
BROWNISH GREY SILTY CLAY WITH LITTLE FINE GRAVEL
TAN SILTY FINE SAND AND ROCK FRAGMENTS
GREY SILTY MEDIUM TO FINE SAND AND ROCK FRAGMENTS
GREY SILTY FINE TO VERY FINE SAND WITH LITTLE FINE GRAVEL AND ROCK FRAGMENTS
GREY SILTY MEDIUM TO FINE SAND WITH LITTLE FINE GRAVEL
TAN MEDIUM SAND
GREY SILTY FINE TO VERY FINE SAND WITH LITTLE FINE GRAVEL
DARK GREY CLAYEY SILT AND DOLOMITE FRAGMENTS (WET)
DOLOMITE BEDROCK; BOTTOM OF BORING (111.5)

Converse/TenEch Geotechnical and Environmental Consultants

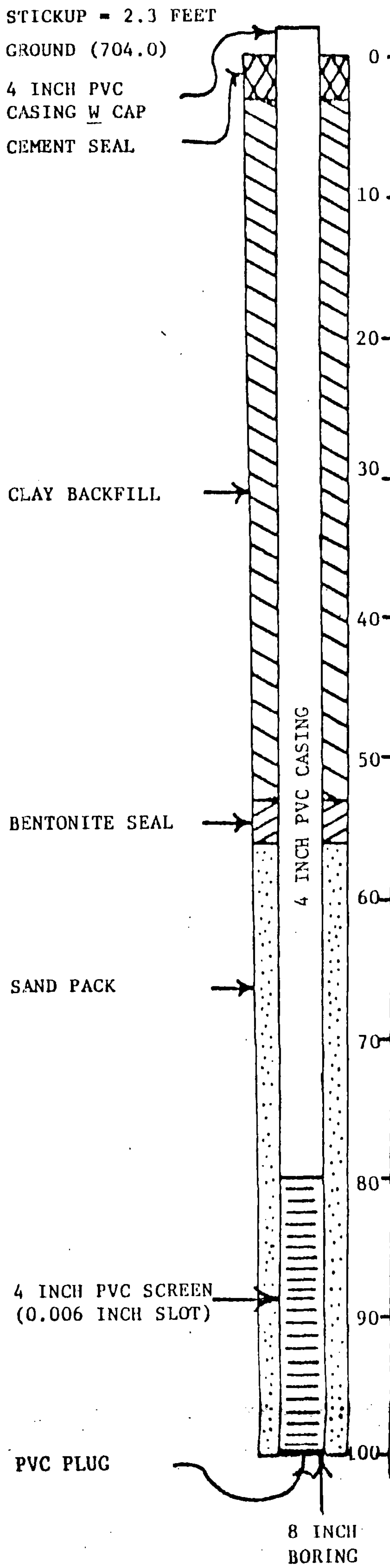
UNION OIL - CHICAGO REFINERY
HYDROGEOLOGIC INVESTIGATION
APPENDIX A
MW-1
BORING LOG AND WELL DETAILS

WELL CONSTRUCTION DETAILS	GENERALIZED LITHOLOGIC DESCRIPTION



GENERALIZED LITHOLOGIC DESCRIPTION
BROWN MOTTLED TAN SILTY CLAY WITH LITTLE ORGANIC MATERIAL
BROWN MOTTLED TAN AND GREY SILTY CLAY WITH TRACE FINE GRAVEL
BROWN MOTTLED GREY SILTY CLAY WITH LITTLE COARSE GRAVEL
BROWN MOTTLED DARK GREY TO BLACK SILTY CLAY WITH TRACE FINE GRAVEL
BROWN CLAYEY FINE SAND WITH SOME MEDIUM TO COARSE GRAVEL
BROWN MEDIUM SAND
BROWN SILTY CLAY WITH LITTLE TO TRACE MEDIUM GRAVEL
GREY SILTY CLAY WITH TRACE MEDIUM TO COARSE GRAVEL
BROWNISH GREY SILTY CLAY WITH TRACE FINE GRAVEL
GREYISH BROWN SANDY CLAY WITH SOME FINE GRAVEL
GREY SILTY MEDIUM TO COARSE SAND
GREY SILTY CLAY WITH TRACE FINE GRAVEL
GREY CLAYEY SILTY FINE TO MEDIUM SAND WITH LITTLE FINE GRAVEL AND ROCK FRAGMENTS
DARK GREY CLAYEY SILT AND DOLOMITE FRAGMENTS (WET)
DOLOMITE BEDROCK; BOTTOM OF BORING (116.5)

WELL CONSTRUCTION DETAILS	GENERALIZED LITHOLOGIC DESCRIPTION



GENERALIZED LITHOLOGIC DESCRIPTION
GREY SILTY CLAY WITH SOME FINE GRAVEL
BROWN SILTY CLAY WITH LITTLE FINE GRAVEL
TAN CLAYEY SILT WITH SOME FINE GRAVEL
GREY CLAY WITH LITTLE FINE GRAVEL
GREY SILTY CLAY WITH TRACE FINE GRAVEL
SILTY FINE GRAVEL AND COARSE SAND
GREY CLAYEY SILT WITH SOME FINE TO MEDIUM GRAVEL
BROWNISH GREY CLAYEY SILT WITH LITTLE FINE GRAVEL
BROWN SILTY FINE SAND WITH LITTLE FINE GRAVEL
GREY SILTY FINE SAND WITH SOME FINE GRAVEL
GREY SILTY FINE SAND WITH LITTLE FINE GRAVEL AND ROCK FRAGMENTS
TAN MEDIUM SAND WITH TRACE SILT
GREY CLAYEY/SILTY FINE SAND WITH LITTLE FINE GRAVEL AND ROCK FRAGMENTS
DARK GREY CLAYEY SILT AND DOLOMITE FRAGMENTS (WET)
DOLOMITE BEDROCK; BOTTOM OF BORING (101.5)

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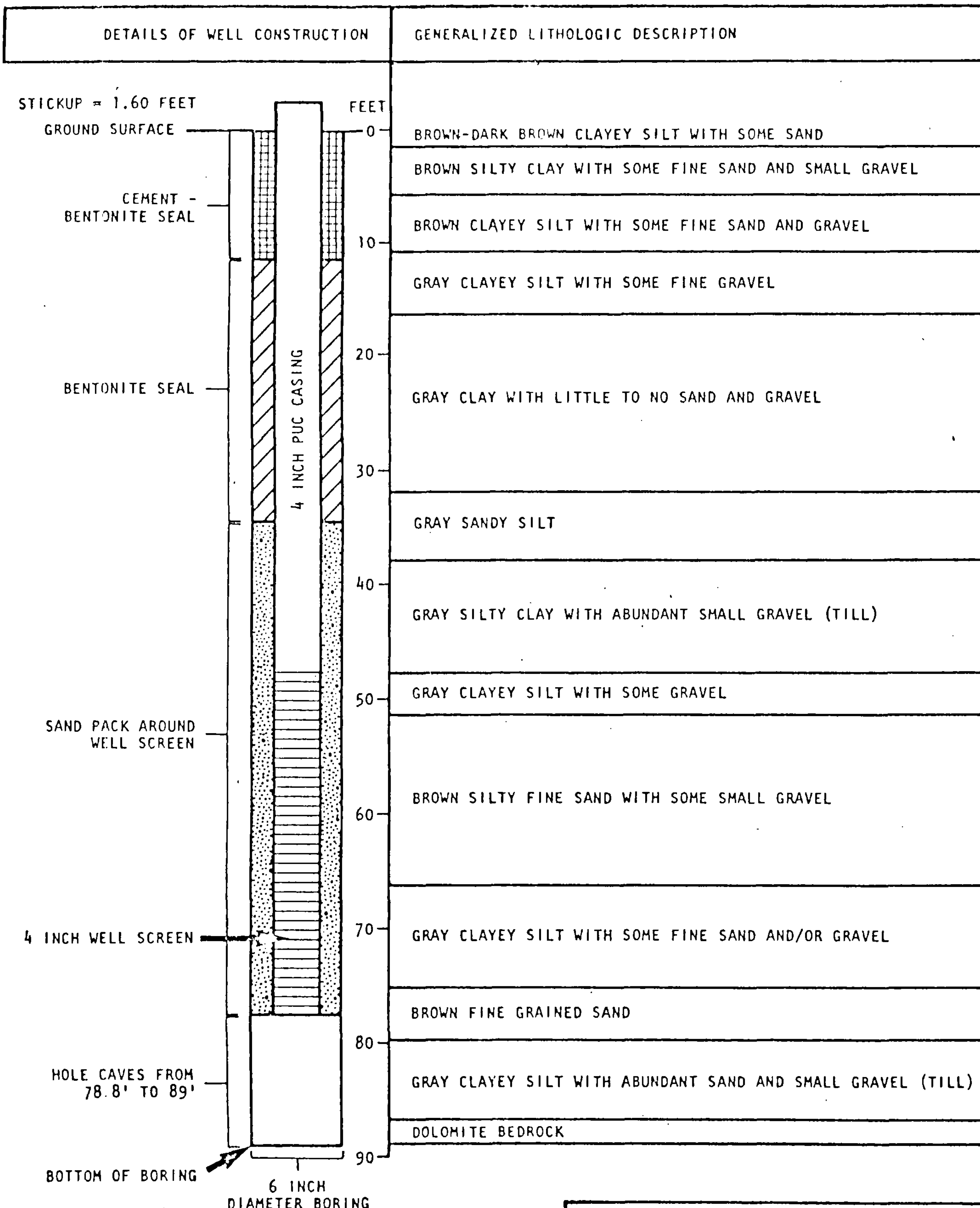
UNION OIL - CHICAGO REFINERY
HYDROGEOLOGIC INVESTIGATION
APPENDIX A
MW-3
BORING LOG AND WELL DETAILS

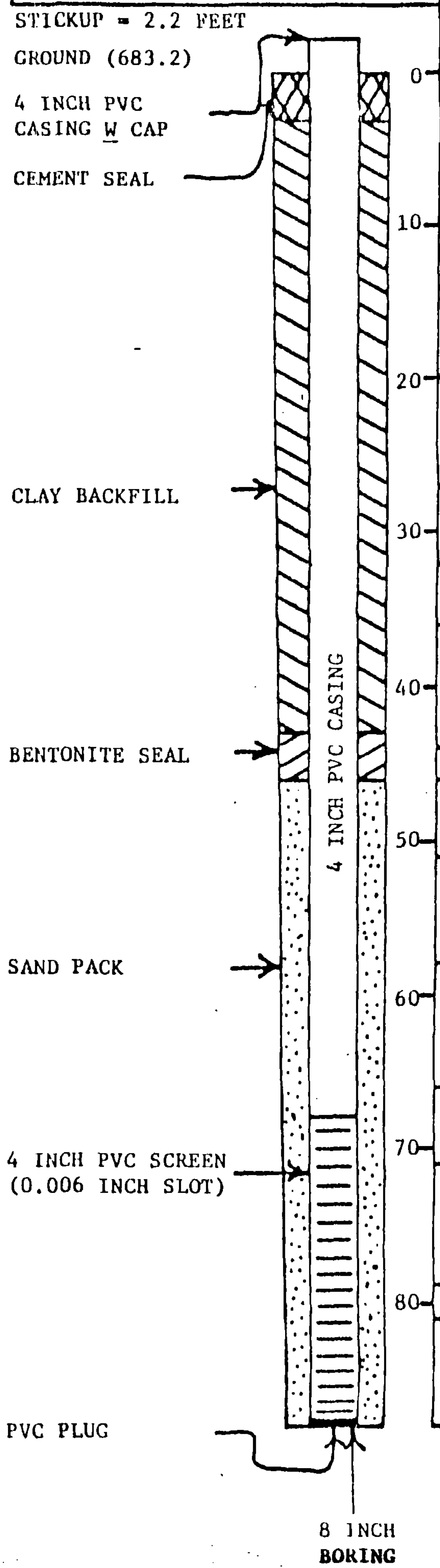


UNION OIL OF CALIFORNIA

FIGURE 3

LITHOLOGIC DESCRIPTION AND WELL CONSTRUCTION SPECIFICATIONS FOR WELL NO. 4

WELL CONSTRUCTION DETAILS	GENERALIZED LITHOLOGIC DESCRIPTION

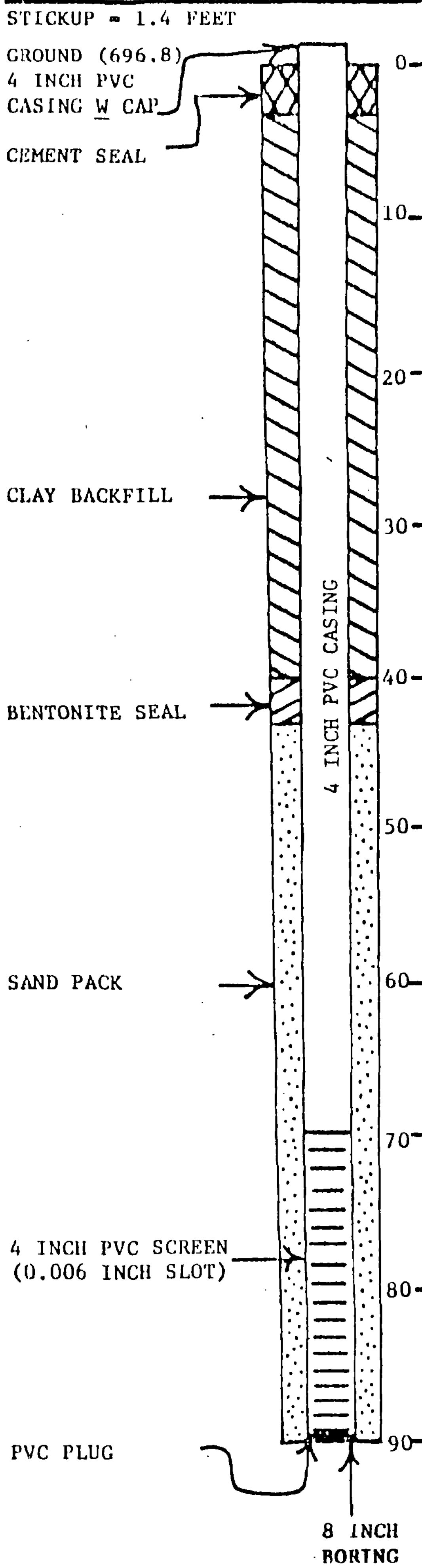


GENERALIZED LITHOLOGIC DESCRIPTION
BROWN CLAYEY SILT WITH LITTLE TO TRACE FINE GRAVEL
TAN SILTY COARSE SAND WITH LITTLE FINE GRAVEL
GREY SILTY SAND WITH LITTLE FINE GRAVEL AND ROCK FRAGMENTS
GREY CLAYEY SILT WITH FEW ROCK FRAGMENTS
TAN SILTY FINE SAND WITH SOME FINE GRAVEL
GREY SILTY FINE SAND WITH SOME FINE TO MEDIUM GRAVEL
TAN SILTY VERY FINE TO MEDIUM SAND
TAN MEDIUM SAND
TAN FINE TO COARSE SAND WITH LITTLE FINE GRAVEL
GREY CLAYEY SILT WITH TRACE FINE GRAVEL
GREY FINE TO MEDIUM SAND
GREYISH TAN SILTY FINE SAND WITH SOME FINE TO MEDIUM GRAVEL
DARK GREY CLAYEY SILT WITH LITTLE FINE GRAVEL (WET)
DOLOMITE BEDROCK; BOTTOM OF BORING (88.0)

Converse/TenEch Geotechnical and Environmental Consultants

UNION OIL - CHICAGO REFINERY
HYDROGEOLOGIC INVESTIGATION
APPENDIX A
MW-5
BORING LOG AND WELL DETAILS

WELL CONSTRUCTION DETAILS	GENERALIZED LITHOLOGIC DESCRIPTION



GENERALIZED LITHOLOGIC DESCRIPTION
BROWN SILT WITH LITTLE ORGANIC MATERIAL
TAN MOTTLED GREY CLAYEY SILT WITH LITTLE FINE GRAVEL
TAN SILTY MEDIUM SAND WITH SOME FINE GRAVEL
DARK GREY CLAYEY SILT WITH TRACE FINE GRAVEL
GREYISH TAN SILTY FINE TO COARSE GRAVEL WITH SOME FINE SAND
DARK GREY CLAYEY SILT WITH SOME FINE TO COARSE GRAVEL
GREYISH TAN SILTY FINE TO COARSE GRAVEL WITH SOME FINE SAND
DARK GREY CLAYEY SILT WITH TRACE MEDIUM GRAVEL
GREYISH TAN SILTY MEDIUM SAND WITH ROCK FRAGMENTS
GREY CLAYEY/SILTY FINE TO MEDIUM SAND WITH LITTLE FINE GRAVEL AND ROCK FRAGMENTS
GREY FINE TO COARSE SAND
GREY CLAYEY FINE SAND WITH TRACE COARSE GRAVEL
GREY CLAYEY SILT WITH TRACE FINE GRAVEL
BROWNISH GREY CLAYEY FINE SAND (WET)
DOLOMITE BEDROCK; BOTTOM OF BORING (91.5)

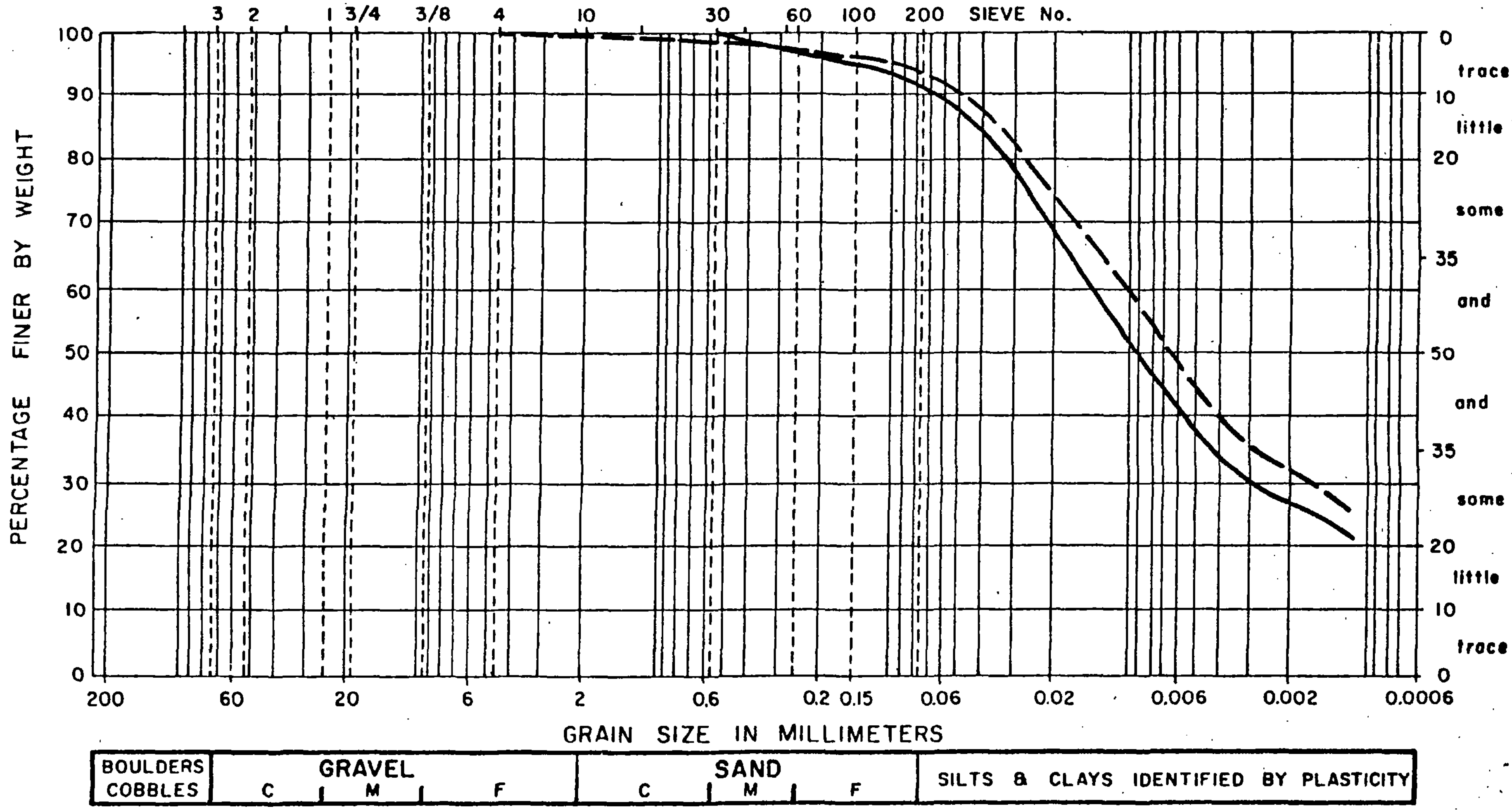
APPENDIX B

GRAIN SIZE DISTRIBUTION CURVES

(USDA TEXTURAL CLASSIFICATION)

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



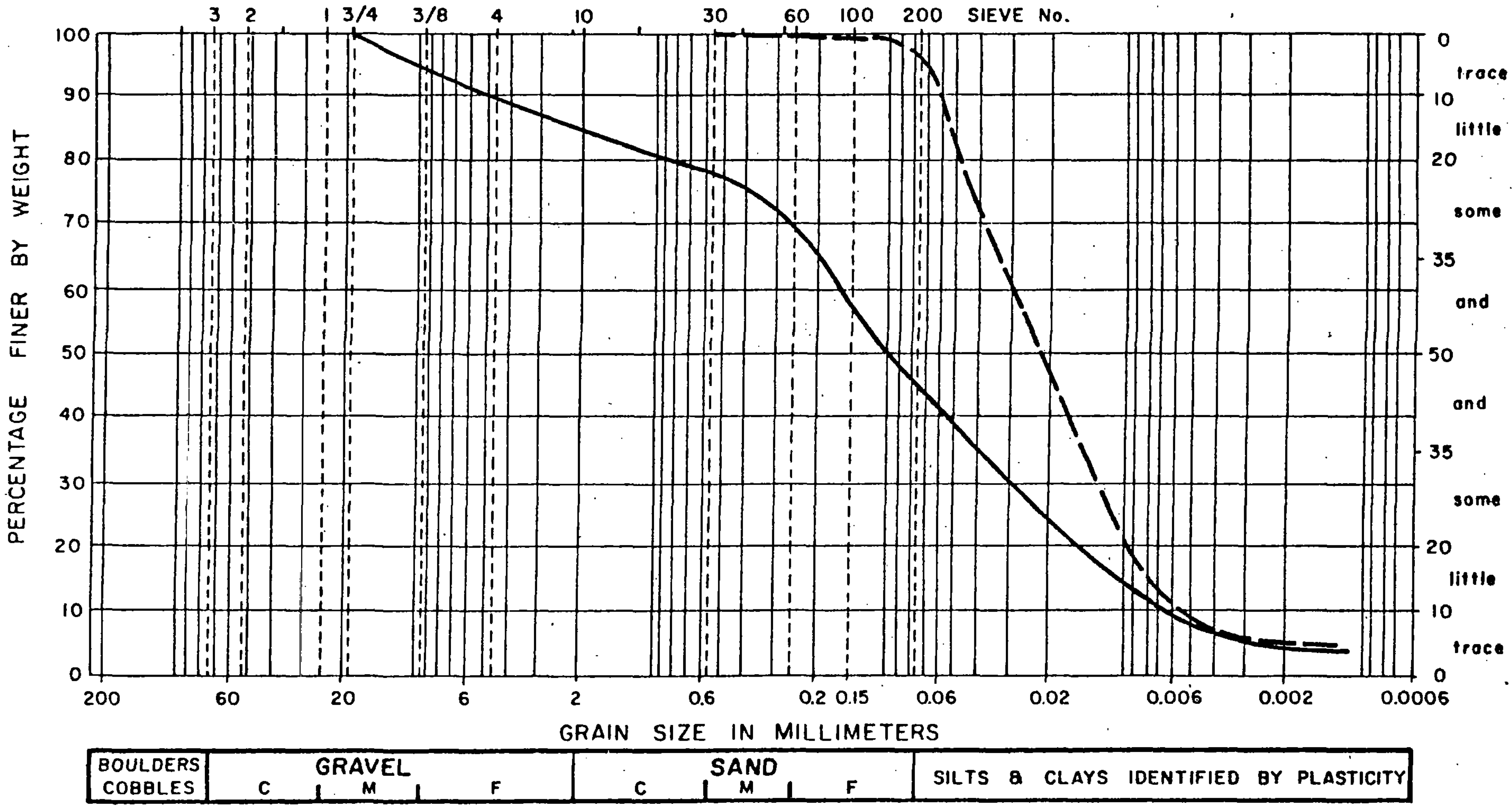
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-1	S-1	0.0' - 1.5'	Dark brown Silty clay loam
— — —	MW-1	S-6	25.0' - 26.5'	Dark gray Silty clay loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



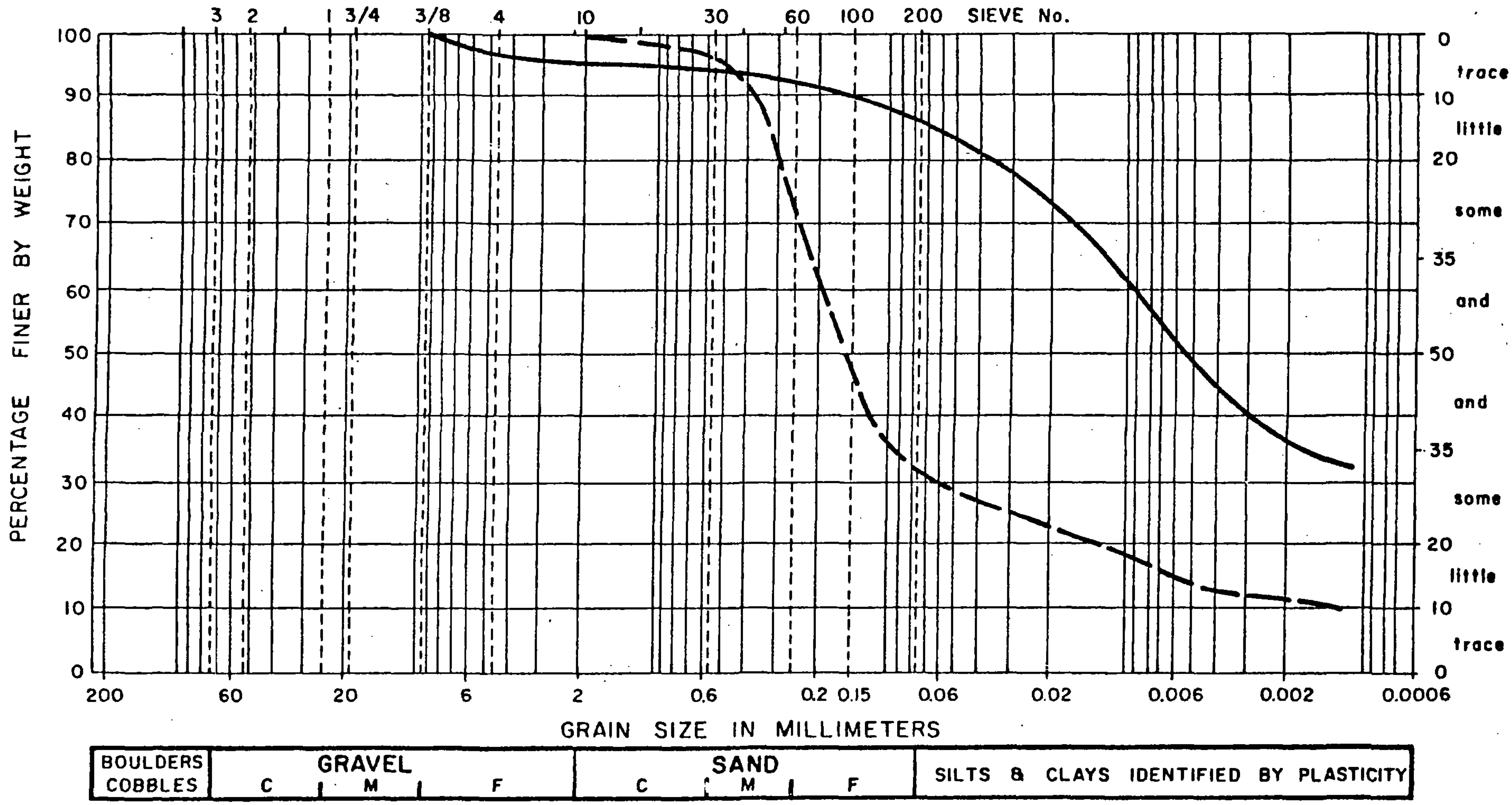
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-1	S-18	85.0' - 86.5'	Light gray Gravelly Silty loam
— — —	MW-1	S-21	100.0' - 101.5'	Light gray Silty loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



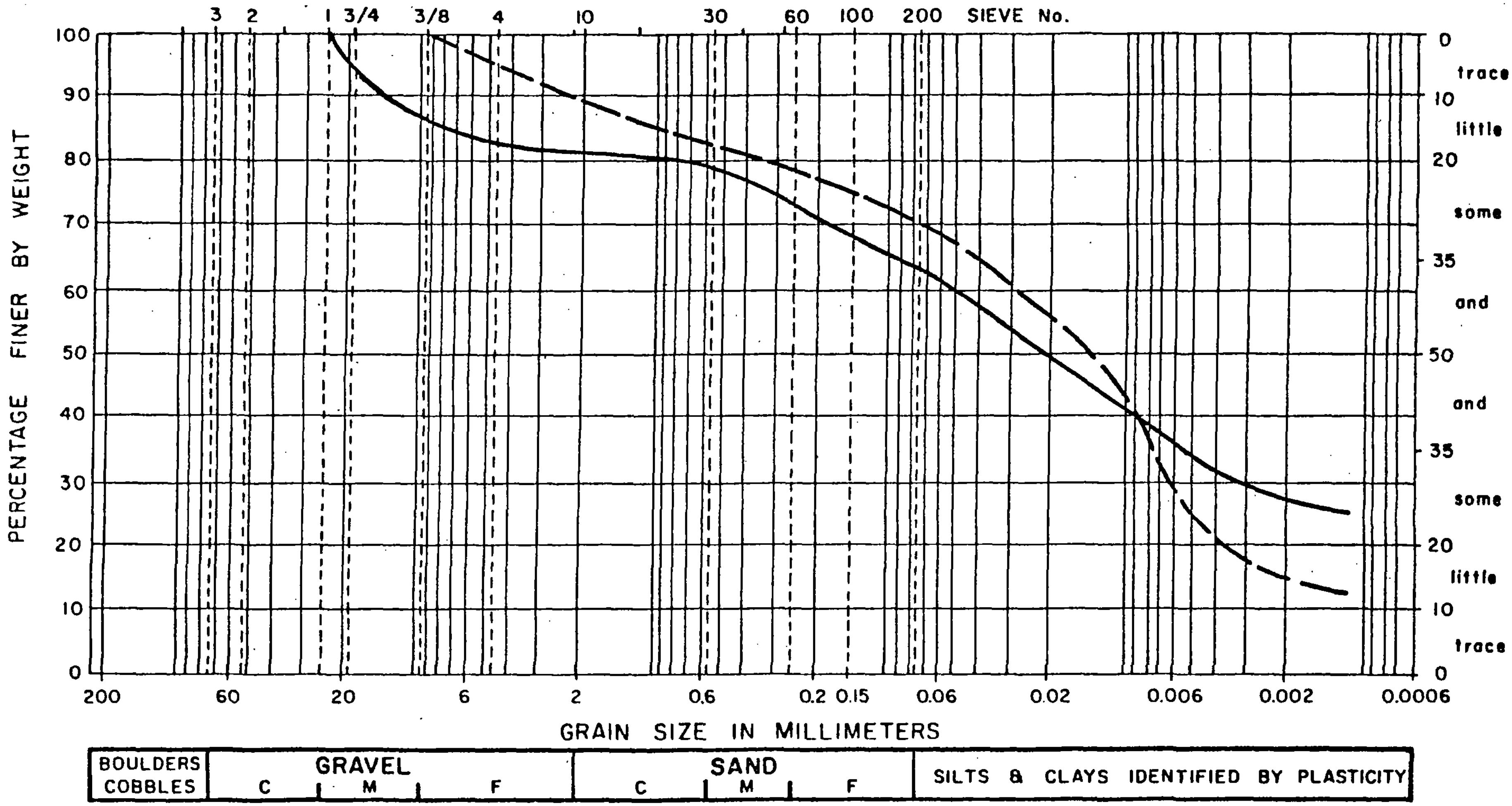
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-2	S-1	0.0' - 1.5'	Brown Silty clay loam
— — —	MW-2	S-6	25.0' - 26.5'	Brown Sandy loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



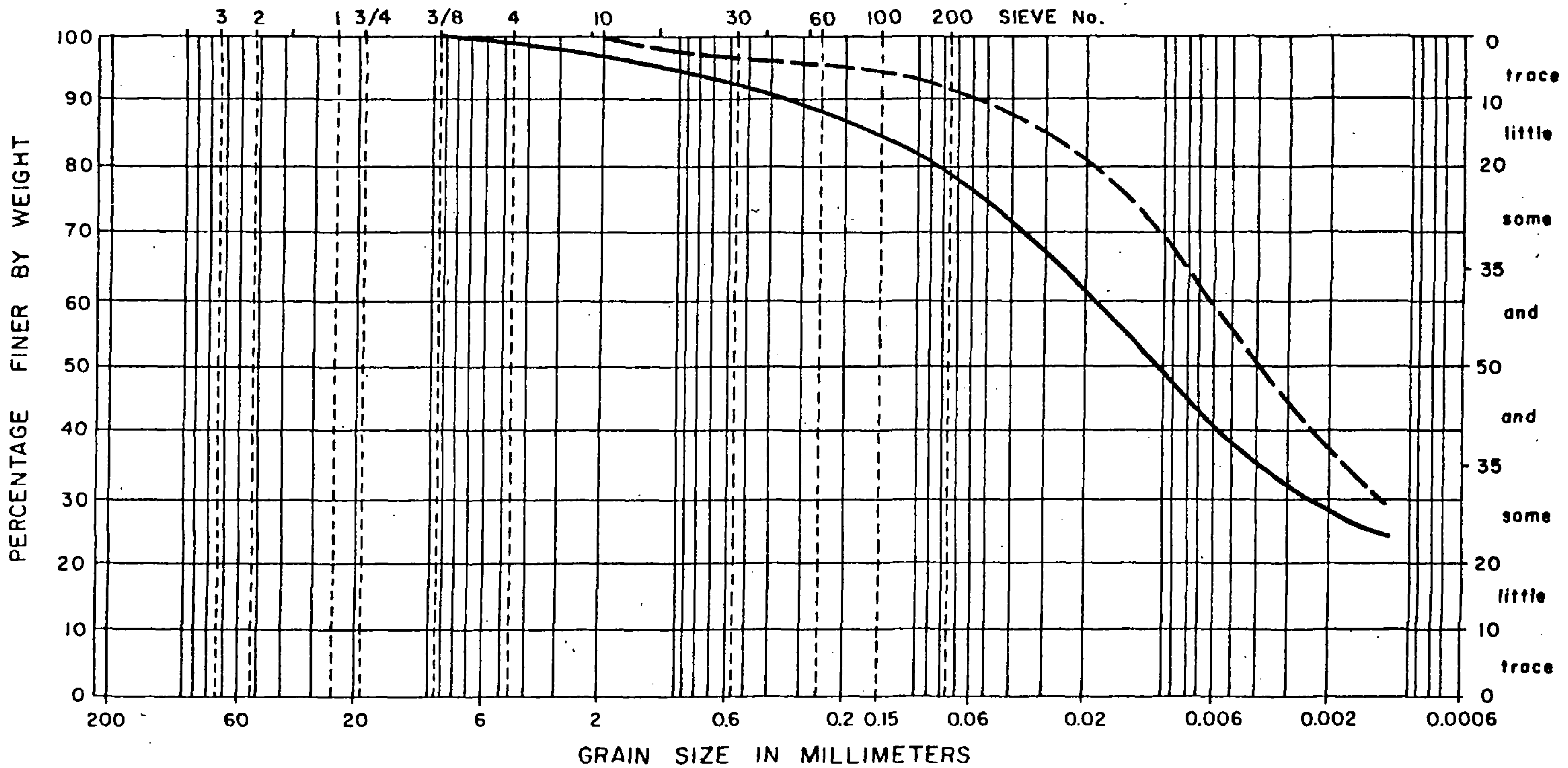
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-2	S-18	85.0' - 86.5'	Light gray Gravelly Clay loam
— — —	MW-2	S-21	100.0' - 101.5'	Gray Gravelly Silty loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



BOULDERS COBBLES	GRAVEL			SAND			SILTS & CLAYS IDENTIFIED BY PLASTICITY
	C	M	F	C	M	F	

SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-3	S-1	3.5' - 5.0'	Brown Silty clay loam
— — —	MW-3	S-6	29.5' - 30.0'	Dark gray Silty clay loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

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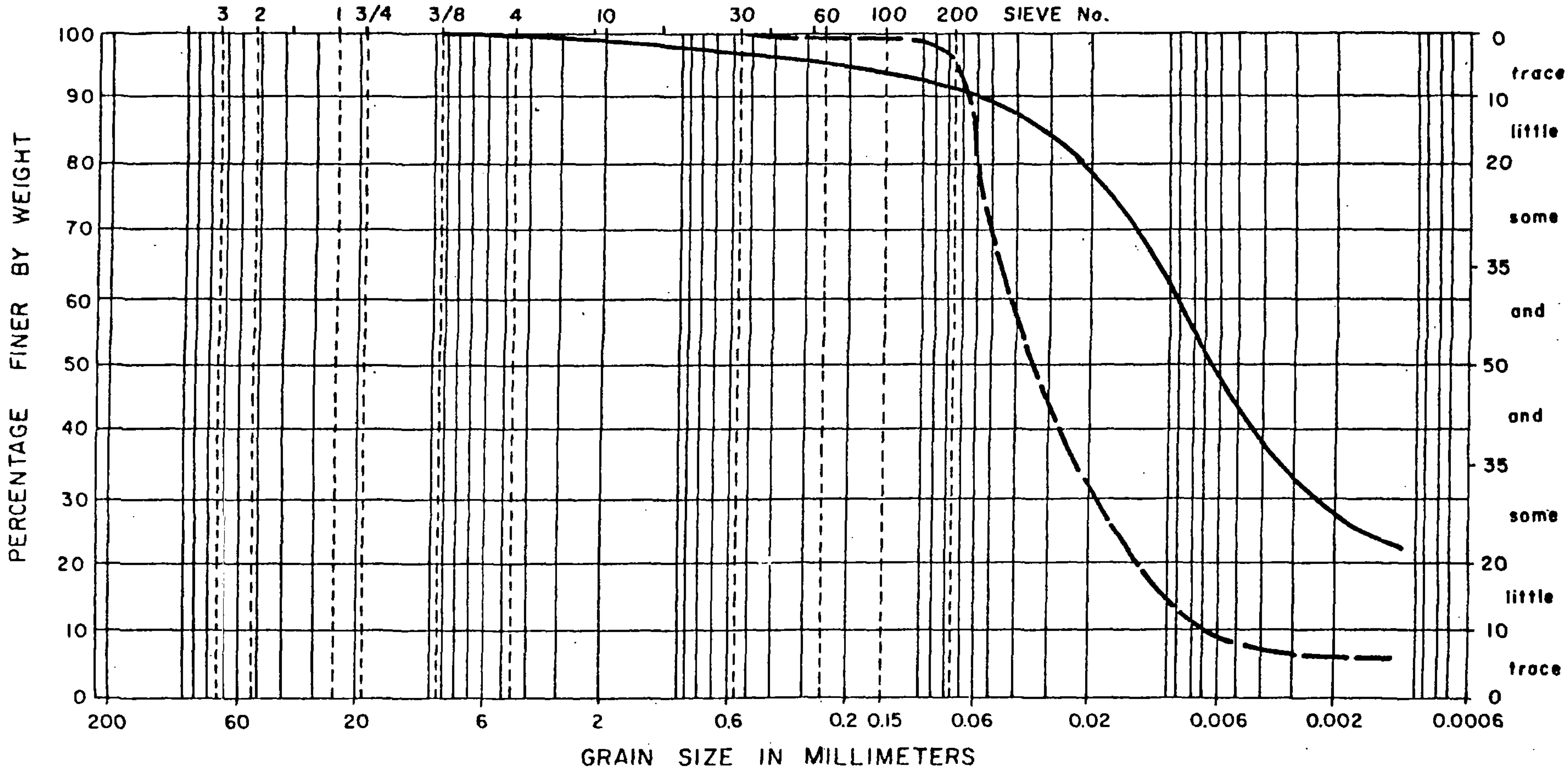
GRAIN SIZE DISTRIBUTION



BOULDERS COBBLES	GRAVEL			SAND			SILTS & CLAYS IDENTIFIED BY PLASTICITY
	C	M	F	C	M	F	

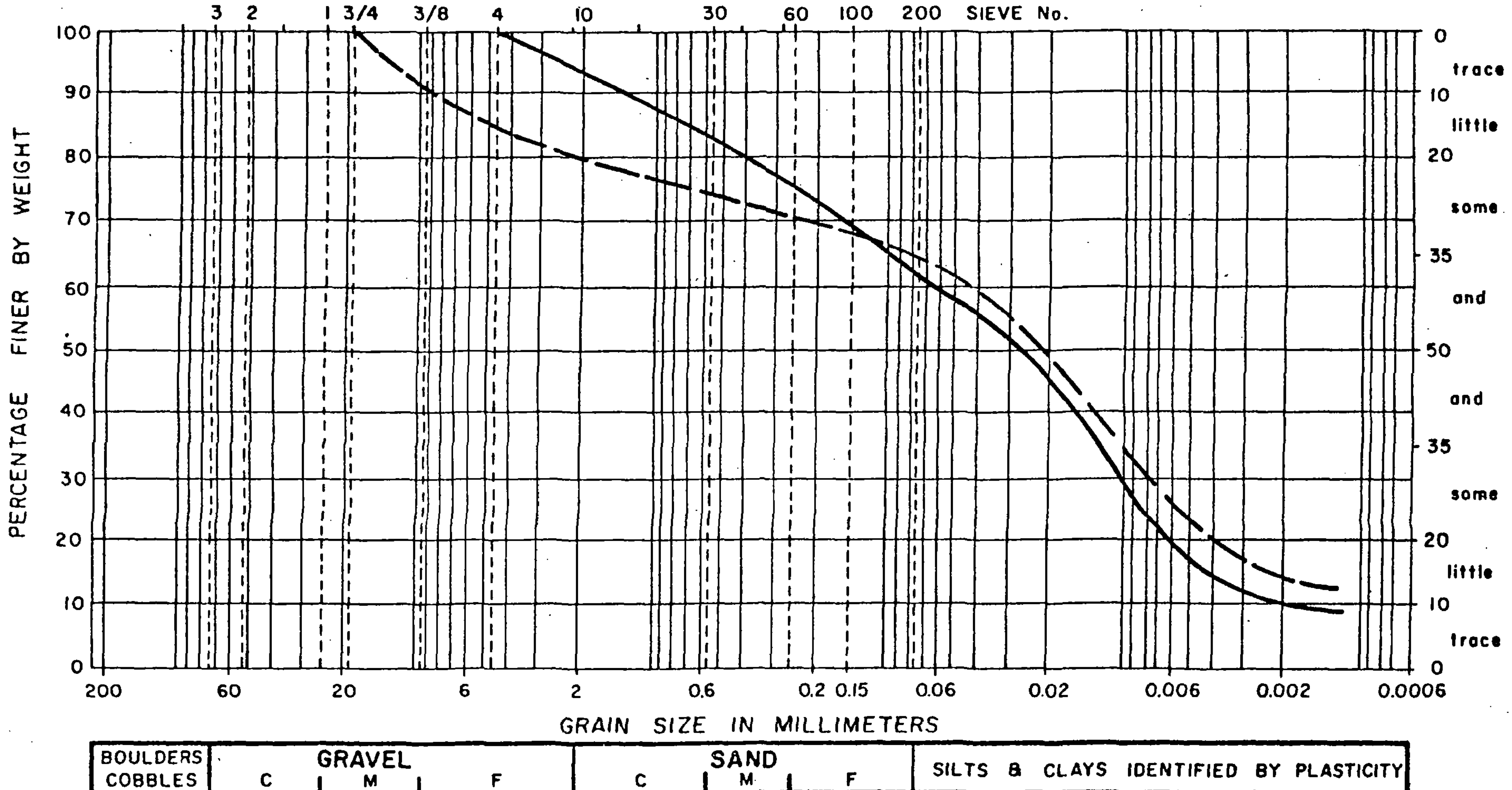
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-3	S-11	53.5' - 55.0'	Dark gray Silty clay loam
— —	MW-3	S-17	85.5' - 86.5'	Light gray Silt

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



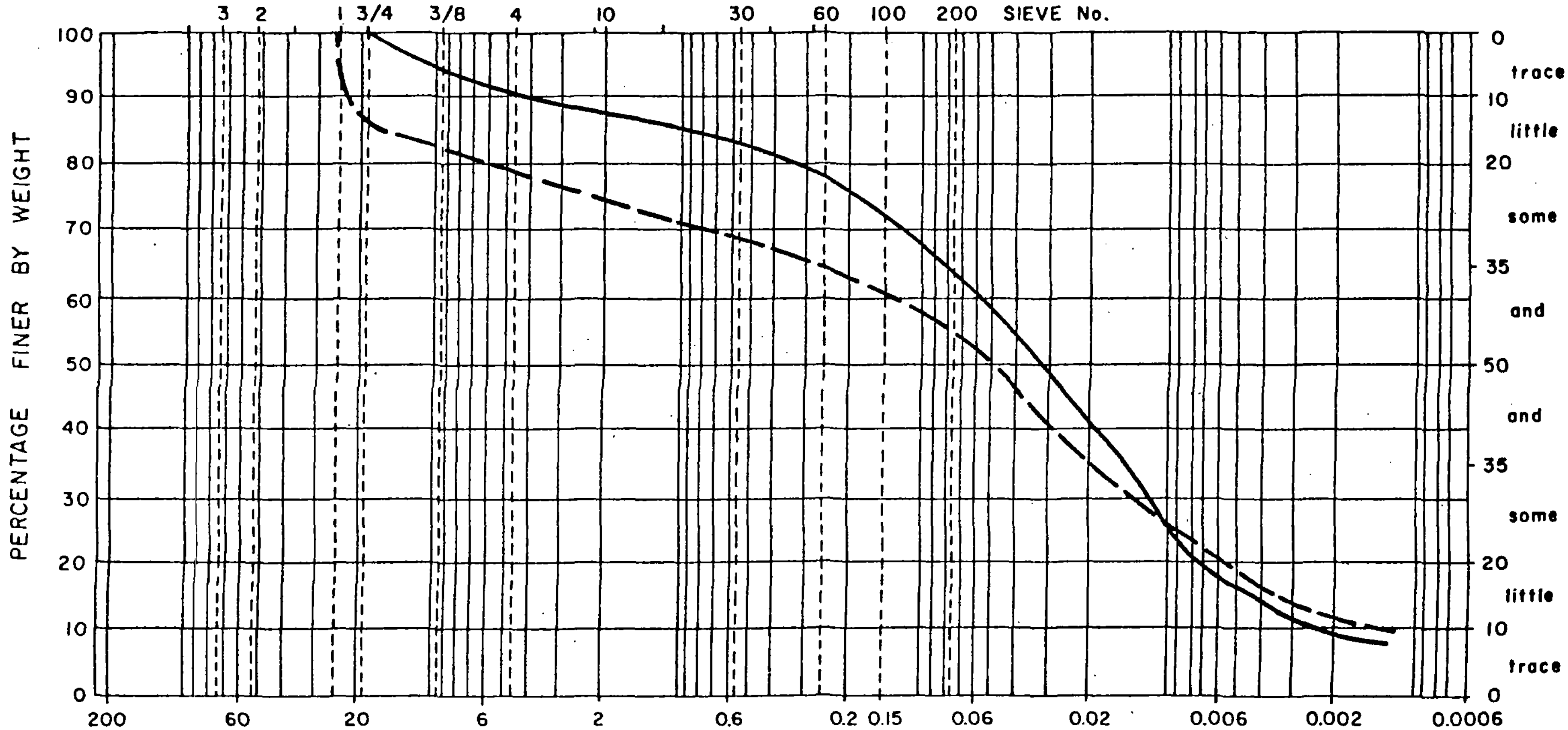
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-5	S-1	3.5' - 5.0'	Brown Silty loam
— — —	MW-5	S-5	23.5' - 25.0'	Gray Gravelly Silty loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



BOULDERS COBBLES	GRAVEL C	GRAVEL M	GRAVEL F	SAND C	SAND M	SAND F	SILTS & CLAYS IDENTIFIED BY PLASTICITY

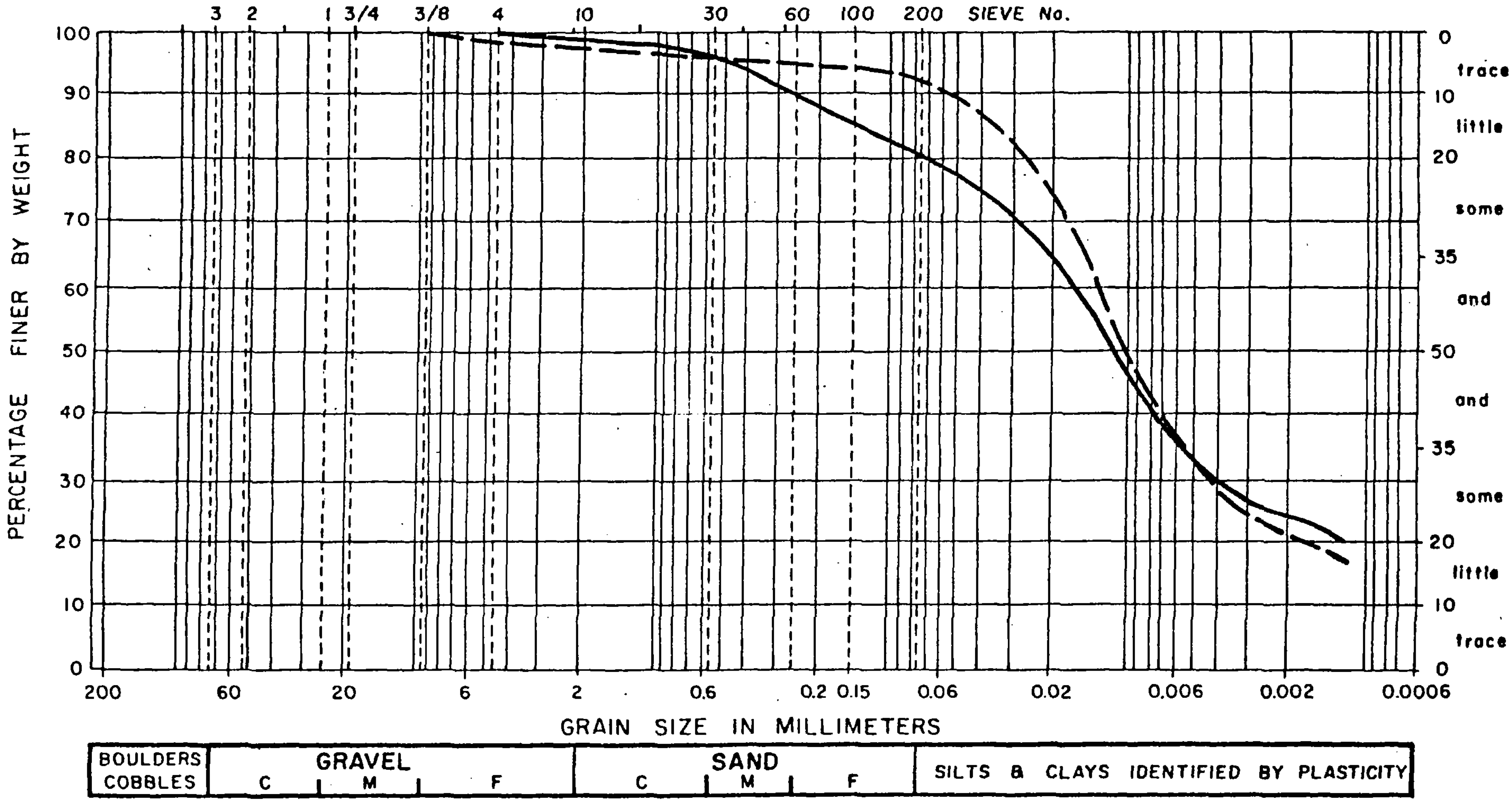
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-5	S-8	38.5' - 40.0'	Light gray Gravelly Silty loam
— — —	MW-5	S-15	73.5' - 75.0'	Light gray Gravelly Silty loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



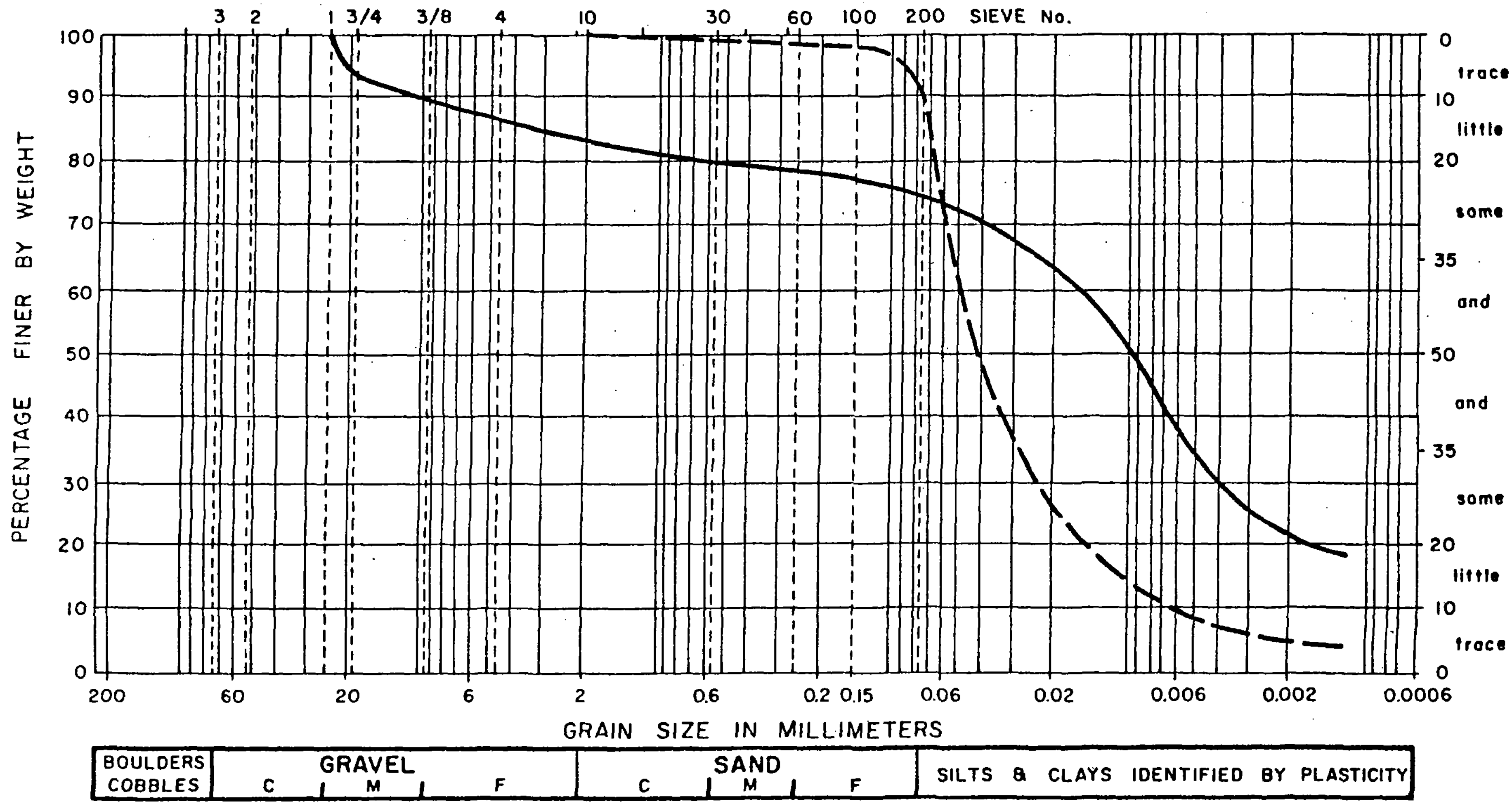
SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
———	MW-6	S-1	0.5' - 2.0'	Brown Silty loam
— — —	MW-6	S-5	20.0' - 21.5'	Dark gray Silty loam

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

ConverseWardDavisDixon

GRAIN SIZE DISTRIBUTION



SYMBOL	BORING	SAMPLE	DEPTH	IDENTIFICATION
————	MW-6	S-9	40.0' - 41.5'	Gray Gravelly Silty loam
— — —	MW-6	S-17	80.0' - 81.5'	Light gray Silt

PROJECT LOCATION Lemont, Illinois BY G.P. DATE 5-11-81 PROJECT No. 81-06103-02

6-79

APPENDIX C

CHEMICAL LABORATORY ANALYSIS - SOILS

REPORT NUMBER F118-228

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: CONVERSE WARD DAVIS
GLENN WITTMAN
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-1 (MW-1)

SAMPLES SUBMITTED BY:

DATE OF REPORT 05/01/81 PAGE 1

SOIL ANALYSIS REPORT

SAMPLE DEPTH (FEET)	LAB NUMBER	ORGANIC MATTER % * RATE	ORGANIC MATTER ** ENR lbs./A	PHOSPHORUS P1 (Weak Bray) * **** ppm P RATE	PHOSPHORUS P2 NaHCO3-P * **** ppm P RATE	POTASSIUM K * ***** ppm K RATE	MAGNESIUM Mg * *** ppm Mg RATE	CALCIUM Ca * *** ppm Ca RATE	SODIUM Na * *** ppm Na RATE	pH SOIL pH	pH BUFFER pH	HYDROGEN H meq/100g	Cation Exchange Capacity C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
0'	7198	1.2	42 VL	3 VL	7 VL	81 L	620 VH	1300 L		6.4	6.3	1.2	13.6	1.5	41.7	47.8	8.8	0.0
5'	7199	0.6	35 VL	1 VL	2 VL	55 VL	350 VH	2000 H		8.2		0.0	13.0	1.1	22.5	76.4	0.0	0.0
25'	7200	2.5	74 M	1 VL	5 VL	92 L	290 VH	1900 H		8.2		0.0	12.1	1.9	19.9	78.2	0.0	0.0
50'	7201	3.9	102 H	1 VL	3 VL	115 M	260 VH	1900 H		8.0		0.0	11.9	2.5	18.1	79.4	0.0	0.0

(SEE EXPLANATION ON BACK)

SAMPLE NUMBER	NITRATE NO3 ppm NO3-N RATE	SULFUR S ppm S RATE	ZINC Zn ppm Zn RATE	MANGANESE Mn ppm Mn RATE	IRON Fe ppm Fe RATE	COPPER Cu ppm Cu RATE	BORON B ppm B RATE	EXCESS LIME RATE	SOLUBLE SALTS mmhos/cm RATE	CHLORIDE Cl ppm Cl RATE	MOLYBDENUM Mo ppm Mo RATE	PARTICAL SIZE ANALYSIS % SAND	% SILT	% CLAY	SOIL TEXTURE

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

BY J. R. ZWIRP

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), VERY HIGH (VH), AND NONE (N).
** ENR - ESTIMATED NITROGEN RELEASE
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P_2O_5
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE K_2O

REPORT NUMBER F118-22

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: GLENN WITTMAN
CONVERSE WARD DAVIS DIXO
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-1 (MW-1)

SAMPLES SUBMITTED BY

DATE 04/30/81 PAGE 1

SOIL FERTILITY RECOMMENDATIONS (lbs./A)

YOUR SAMPLE NUMBER	CROP	YIELD	AMENDMENTS: LIME LB/A OF CaCO3	LIME TONS/A	GYPSUM TONS/A	ELEMENTAL SULFUR LBS/A	N NITROGEN	P_2O_5 PHOSPHATE	K_2O POTASH	Mg MAGNESIUM	S SULFUR	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	B BORON	Mo MOLYBDENUM	REFER SECTION
1	CORN	140 BU		0.0			190	130	180									
1	SOYBEANS	40 BU		0.0			5	80	135									
2	CORN	140 BU		0.0			200	135	180									
2	SOYBEANS	40 BU		0.0			5	80	140									
6	CORN	140 BU		0.0			180	135	180									
6	SOYBEANS	40 BU		0.0			5	80	140									
11	CORN	140 BU		0.0			165	135	100									
11	SOYBEANS	40 BU		0.0			5	80	60									

REMARKS

A & L GREAT LAKES AGRICULTURAL LABORATORIES INC
BY

REPORT NUMBER F115-23

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: GLENN WITTMAN
CONVERSE WARD DAVIS
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-2 (MW-2)

SAMPLES SUBMITTED BY:

DATE OF REPORT 04/30/81 PAGE 1

SOIL ANALYSIS REPORT

SAMPLE DEPTH (FEET)	LAB NUMBER	ORGANIC MATTER % * RATE	ORGANIC MATTER ** ENR lbs./A	PHOSPHORUS P_1 (Weak Bray) **** ppm-P RATE	PHOSPHORUS P_2 $NaHCO_3$-P **** ppm-P RATE	POTASSIUM K ***** ppm-K RATE	MAGNESIUM Mg * ppm-Mg RATE	CALCIUM Ca * ppm-Ca RATE	SODIUM Na * ppm-Na RATE	pH SOIL pH	pH BUFFER pH	HYDROGEN H meq/100g	Cation Exchange Capacity C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
1 0'	7202	1.4	52 L	2 VL	6 VL	77 L	365 VH	1250 M		6.7	7.0	0.4	9.9	2.0	30.7	63.1	4.0	0.[illegible]
2 5'	7203	0.4	30 VL	1 VL	2 VL	43 VL	325 VH	2100 H		8.2		0.0	13.3	0.9	20.3	78.8	0.0	0.[illegible]
6 25'	7204	1.0	44 VL	1 VL	8 L	24 VL	90 M	1500 VH		8.1		0.0	6.3	0.7	9.0	90.2	0.0	0.[illegible]
11 50'	7205	1.1	46 VL	1 VL	10 L	45 VL	235 VH	1050 H		8.4		0.0	7.3	1.7	26.7	71.6	0.0	0.[illegible]

(SEE EXPLANATION ON BACK)

SAMPLE NUMBER	NITRATE NO_3 ppm-NO_3-N RATE	SULFUR S ppm-S RATE	ZINC Zn ppm-Zn RATE	MANGANESE Mn ppm-Mn RATE	IRON Fe ppm-Fe RATE	COPPER Cu ppm-Cu RATE	BORON B ppm-B RATE	EXCESS LIME RATE	SOLUBLE SALTS mmhos/cm RATE	CHLORIDE Cl ppm-Cl RATE	MOLYBDENUM Mo ppm-Mo RATE	PARTICAL SIZE ANALYSIS % SAND	% SILT	% CLAY	SOIL TEXTURE

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

BY J. R. ZWIEP

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), VERY HIGH (VH), AND NONE (N)
** ENR - ESTIMATED NITROGEN RELEASE
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P_2O_5
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE K_2O

EPORT NUMBER F115-23

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: GLENN WITTMAN
CONVERSE WARD DAVIS DIXO
100 TECHNECENTER DR.
MILFORD OH 451.0

GROWER: GLENN WITTMAN
SAMPLES B-2 (MW-2)

SAMPLES SUBMITTED BY

ATE 04/30/81 PAGE 1

SOIL FERTILITY RECOMMENDATIONS (lbs./A)

YOUR SAMPLE NUMBER	CROP	YIELD	AMENDMENTS LIME LB/A OF CaCO3	LIME TONS/A	GYPSUM TONS/A	ELEMENTAL SULFUR LBS/A	N NITROGEN	P_2O_5 PHOSPHATE	K_2O POTASH	Mg MAGNESIUM	S SULFUR	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	B BORON	Mo MOLYBDENUM
1	CORN	140 BU		0.0			190	135	160								
1	SOYBEANS	40 BU		0.0			5	80	125								
2	CORN	140 BU		0.0			200	135	180								
2	SOYBEANS	40 BU		0.0			5	80	140								
6	CORN	140 BU		0.0			205	135	180								
6	SOYBEANS	40 BU		0.0			5	80	140								
11	CORN	140 BU		0.0			195	135	160								
11	SOYBEANS	40 BU		0.0			5	80	140								

EMARKS

A & L GREAT LAKES AGRICULTURAL LABORATORIES INC.
BY

J. R. [illegible]EP

REPORT NUMBER F116-24

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: GLENN WITTMAN
CONVERSE WARD DAVIS
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-3 (MW-3)

SAMPLES SUBMITTED BY:

DATE OF REPORT 04/30/81

PAGE 1

SOIL ANALYSIS REPORT

SAMPLE	DEPTH (FEET)	LAB NUMBER	ORGANIC MATTER % RATE	ORGANIC MATTER ENR lbs./A	PHOSPHORUS P_1 (Weak Bray) ppm-P RATE	PHOSPHORUS P_2 $NaHCO_3$-P ppm-P RATE	POTASSIUM K ppm-K RATE	MAGNESIUM Mg ppm-Mg RATE	CALCIUM Ca ppm-Ca RATE	SODIUM Na ppm-Na RATE	pH SOIL pH	pH BUFFER pH	HYDROGEN H meq/100g	Cation Exchange Capacity C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
1	5'	7206	0.5	52 VL	1 VL	20 M	65 L	550 VH	1700 M		8.2		0.0	13.2	1.3	34.6	64.1	0.0	0.
3	15'	7207	0.6	55 VL	1 VL	2 VL	70 L	550 VH	2100 H		8.4		0.0	13.5	1.3	21.5	77.2	0.0	0.
6	30'	7208	2.1	66 L	1 VL	3 VL	102 L	360 VH	2000 H		8.1		0.0	13.2	2.0	22.6	75.4	0.0	0.
9	45'	7209	1.5	54 L	1 VL	6 VL	74 L	235 VH	1800 H		8.2		0.0	11.1	1.7	17.6	80.7	0.0	0.

(SEE EXPLANATION ON BACK)

SAMPLE NUMBER	NITRATE NO_3 ppm-NO_3-N RATE	SULFUR S ppm-S RATE	ZINC Zn ppm-Zn RATE	MANGANESE Mn ppm-Mn RATE	IRON Fe ppm-Fe RATE	COPPER Cu ppm-Cu RATE	BORON B ppm-B RATE	EXCESS LIME RATE	SOLUBLE SALTS mmhos/cm RATE	CHLORIDE Cl ppm-Cl RATE	MOLYBDENUM Mo ppm-Mo RATE	PARTICAL SIZE ANALYSIS % SAND	% SILT	% CLAY	SOIL TEXTURE

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

BY J. R. ZWIEP

CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), VERY HIGH (VH), AND NONE (N)

•••• MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P_2O_5

REPORT NUMBER F113-24

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: GLENN WITTMAN
CONVERSE WARD DAVIS DIXON
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-3 (MW-3)

SAMPLES SUBMITTED BY

DATE 04/30/81 PAGE 1

SOIL FERTILITY RECOMMENDATIONS (lbs./A)

YOUR SAMPLE NUMBER	CROP	YIELD	AMENDMENTS: LIME LB A OF $CaCO_3$	AMENDMENTS: LIME TONS/A	AMENDMENTS: GYPSUM TONS A	AMENDMENTS: ELEMENTAL SULFUR LBS/A	N NITROGEN	P_2O_5 PHOSPHATE	K_2O POTASH	Mg MAGNESIUM	S SULFUR	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	B BORON	Mo MOLYBDENUM	REFF SECT INDIC ION
1	CORN	140 BU		0.0			200	135	180									
1	SOYBEANS	40 BU		0.0			5	80	140									
3	CORN	140 BU		0.0			200	135	180									
3	SOYBEANS	40 BU		0.0			5	80	140									
6	CORN	140 BU		0.0			185	135	135									
6	SOYBEANS	40 BU		0.0			5	60	95									
9	CORN	140 BU		0.0			190	135	180									
9	SOYBEANS	40 BU		0.0			5	60	140									

REMARKS

A & L GREAT LAKES AGRICULTURAL LABORATORIES INC
BY

J. R. [illegible]

REPORT NUMBER F118-25[illegible]

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: CONVERSE WARD DAVIS
GLENN WITTMAN
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-5 (MW-5)

SAMPLES SUBMITTED BY:

DATE OF REPORT 05/01/81 PAGE 1

SOIL ANALYSIS REPORT

SAMPLE DEPTH (FEET)	LAB NUMBER	ORGANIC MATTER % RATE	ORGANIC MATTER ENR lbs/A	PHOSPHORUS P1 (Weak Bray) ppm P RATE	PHOSPHORUS P2 NaHCO3-P ppm P RATE	POTASSIUM K ppm K RATE	MAGNESIUM Mg ppm Mg RATE	CALCIUM Ca ppm Ca RATE	SODIUM Na ppm Na RATE	pH SOIL pH	pH BUFFER pH	HYDROGEN H meq/100g	Cation Exchange Capacity C.E.C. meq/100g	% K	% Mg	% Ca	% H	% Na
1 5'	0010	0.7	57VL	4 VL	5 VL	2[illegible] VH	490 VH	1800 M		7.3		0.0	13.6	4.2	29.9	65.9	0.0	0.0
2 10'	0011	0.4	30VL	1 VL	6 VL	54 VL	2[illegible]0 VH	1900 H		8.4		0.0	12.0	1.1	20.0	78.8	0.0	0.0
5 25'	0012	2.1	50L	1 VL	6 VL	61 L	235 VH	1850 H		7.9		0.0	11.3	1.4	17.2	81.4	0.0	0.0
12 60'	0013	2.4	72M	1 VL	2 VL	38 VL	145 H	1700 VH		8.0		0.0	9.8	1.0	12.3	85.7	0.0	0.0

(SEE EXPLANATION ON BACK)

SAMPLE NUMBER	NITRATE NO_3 ppm NO_3-N RATE	SULFUR S ppm S RATE	ZINC Zn ppm Zn RATE	MANGANESE Mn ppm Mn RATE	IRON Fe ppm Fe RATE	COPPER Cu ppm Cu RATE	BORON B ppm B RATE	EXCESS LIME RATE	SOLUBLE SALTS mmhos/cm RATE	CHLORIDE Cl ppm Cl RATE	MOLYBDENUM Mo ppm Mo RATE	PARTICAL SIZE ANALYSIS % SAND	% SILT	% CLAY	SOIL TEXTURE

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

BY J. K. ZWIEP

• CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), VERY HIGH (VH), AND NONE (N).
•• ESTIMATED NITROGEN RELEASE
•••• MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P_2O_5
••••• MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE K_2O

REPORT NUMBER

F118-25

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 DECATUR RD. • FORT WAYNE, IN. 46806 • (219) 456-3545

SEND TO
Converse Ward Davis Diox
Glenn Wittman
100 Technecenter Dr.
Milford, OH 45150

GROWER: Glenn Wittman

SAMPLES SUBMITTED BY:

Samples B-5 (MW-5)

DATE 5/4/81 PAGE

SOIL FERTILITY RECOMMENDATIONS (lbs./A)

YOUR SAMPLE NUMBER	ACRES	CROP	YIELD	LIME TONS/A	LIME KIND		N NITROGEN	P_2O_5 PHOSPHATE	K_2O POTASH	Mg MAGNESIUM	S SULFUR	B BORON	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	Mo MOLYBDENUM
1		Corn	140 bu	0			195	125	35								
		Soybeans	40 bu	0			5	75	0								
2		Corn	140 bu	0			200	135	180								
		Soybeans	40 bu	0			5	80	140								
5		Corn	140 bu	0			185	135	180								
		Soybeans	40 bu	0			5	80	140								
12		Corn	140 bu	0			180	135	180								
		Soybeans	40 bu	0			5	80	140								

REMARKS

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

BY

J.R. Zwiep /cm

REPORT NUMBER F115-26

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: GLENN WITTMAN
CONVERSE WARD DAVIS
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-6 (MW-6)

SAMPLES SUBMITTED BY:

DATE OF REPORT 04/30/81 PAGE 1

SOIL ANALYSIS REPORT

SAMPLE	DEPTH (FEET)	LAB NUMBER	ORGANIC MATTER % RATE	ORGANIC MATTER ENR lbs/A	PHOSPHORUS P_1 (Weak Bray) ppm P RATE		PHOSPHORUS P_2 $NaHCO_3$-P ppm P RATE		POTASSIUM K ppm K RATE		MAGNESIUM Mg ppm Mg RATE		CALCIUM Ca ppm Ca RATE		SODIUM Na ppm Na RATE	pH SOIL pH	pH BUFFER pH	HYDROGEN H meq/100g	Cation Exchange Capacity C.E.C. meq/100g	% K	% Mg	% Ca	% H	% Na
1	0'	0014	1.2	48VL	4	VL	9	L	55	VL	135	VH	600	M		5.7	6.9	1.1	5.5	1.7	21.2	56.6	20.5	0.0
2	5'	0015	0.5	32VL	1	VL	2	VL	68	VL	445	VH	2350	H		8.2		0.0	15.6	1.1	23.7	75.2	0.0	0.0
5	20'	0016	2.8	80M	1	VL	9	L	54	VL	175	H	1800	VH		8.2		0.0	10.5	1.3	13.8	84.9	0.0	0.0
11	50'	0017	1.4	52L	1	VL	7	VL	39	VL	130	H	1600	VH		8.3		0.0	9.1	1.1	11.3	87.1	0.0	0.0

(SEE EXPLANATION ON BACK)

SAMPLE NUMBER	NITRATE NO_3 ppm NO_3-N RATE	SULFUR S ppm S RATE	ZINC Zn ppm Zn RATE	MANGANESE Mn ppm Mn RATE	IRON Fe ppm Fe RATE	COPPER Cu ppm Cu RATE	BORON B ppm B RATE	EXCESS LIME RATE	SOLUBLE SALTS mmhos/cm RATE	CHLORIDE Cl ppm Cl RATE	MOLYBDENUM Mo ppm Mo RATE	PARTICAL SIZE ANALYSIS % SAND	% SILT	% CLAY	SOIL TEXTURE

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

BY R. ZWICK

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), VERY HIGH (VH), AND NONE (N)

**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P_2O_5

***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE K_2O

REPORT NUMBER F116-26

A & L GREAT LAKES AGRICULTURAL LABORATORIES, INC.

5011 Decatur Road • Fort Wayne, Indiana 46806 • (219) 456-3545

SEND TO: GLENN WITTMAN
CONVERSE WARD DAVIS DIXO
100 TECHNECENTER DR.
MILFORD OH 45150

GROWER: GLENN WITTMAN
SAMPLES B-6 (MW-6)

SAMPLES SUBMITTED BY

DATE 04/30/81 PAGE 1

SOIL FERTILITY RECOMMENDATIONS (lbs./A)

YOUR SAMPLE NUMBER	CROP	YIELD	AMENDMENTS: LIME LB A OF $CaCO_3$	AMENDMENTS: LIME TONS/A	AMENDMENTS: GYPSUM TONS/A	AMENDMENTS: ELEMENTAL SULFUR LBS/A	N NITROGEN	P_2O_5 PHOSPHATE	K_2O POTASH	Mg MAGNESIUM	S SULFUR	Zn ZINC	Mn MANGANESE	Fe IRON	Cu COPPER	B BORON	Mo MOLYBDENUM	REFER SECTION INDICA-TION BA[illegible]
1	CORN	140 BU		1.5			190	125	180									
1	SOYBEANS	40 BU		1.5			5	75	140									
2	CORN	140 BU		0.0			200	135	180									
2	SOYBEANS	40 BU		0.0			5	80	140									
5	CORN	140 BU		0.0			175	135	180									
5	SOYBEANS	40 BU		0.0			5	80	140									
11	CORN	140 BU		0.0			190	135	180									
11	SOYBEANS	40 BU		0.0			5	80	140									

REMARKS

A & L GREAT LAKES AGRICULTURAL LABORATORIES INC.
BY

APPENDIX D

UNIFIED AND USDA SOIL CLASSIFICATION

UNION OIL - CHICAGO REFINERY

HYDROGEOLOGIC INVESTIGATION

APPENDIX D

UNIFIED AND USDA TEXTURAL CLASSIFICATIONS OF BORING SAMPLES

BORING	SAMPLE	DEPTH (FT.)	UNIFIED GROUP SYMBOL	ESTIMATED PERMEABILITY (cm/sec)	USDA TEXTURAL CLASSIFICATION
B-1	S-1	0.0 to 1.5	CL	10^{-6} to 10^{-8}	Dark brown silty clay loam
	S-6	25.0 to 26.5	CH	10^{-6} to 10^{-8}	Dark grey silty clay loam
	S-18	85.0 to 86.5	ML	10^{-3} to 10^{-6}	Light grey gravelly silty loam
	S-21	100.0 to 101.5	ML	10^{-3} to 10^{-6}	Light grey silty loam
B-2	S-1	0.0 to 1.5	CL	10^{-6} to 10^{-8}	Brown silty clay loam
	S-6	25.0 to 26.5	SM	10^{-3} to 10^{-6}	Brown sandy loam
	S-18	85.0 to 86.5	ML	10^{-3} to 10^{-6}	Light grey gravelly clay loam
	S-21	100.0 to 101.5	CL	10^{-6} to 10^{-8}	Grey gravelly silty loam
B-3	S-1	3.5 to 5.0	CL	10^{-6} to 10^{-8}	Brown silty clay loam
	S-6	29.5 to 30.0	CH	10^{-6} to 10^{-8}	Dark grey silty clay loam
	S-11	53.5 to 55.0	CH	10^{-6} to 10^{-8}	Dark grey silty clay loam
	S-17	85.5 to 86.5	ML	10^{-3} to 10^{-6}	Light grey silt
B-5	S-1	3.5 to 5.0	CL	10^{-6} to 10^{-8}	Brown silty loam
	S-5	23.5 to 25.0	ML-CL	10^{-5} to 10^{-7}	Grey gravelly silty loam
	S-8	38.5 to 40.0	ML-CL	10^{-5} to 10^{-7}	Light grey gravelly silty loam
	S-15	73.5 to 75.0	CL	10^{-6} to 10^{-8}	Light grey gravelly silty loam
B-6	S-1	0.5 to 2.0	ML-CL	10^{-5} to 10^{-7}	Brown silty loam
	S-5	20.0 to 21.5	CL	10^{-6} to 10^{-8}	Dark grey silty loam
	S-9	40.0 to 41.5	CL	10^{-6} to 10^{-8}	Grey gravelly silty loam
	S-17	80.0 to 81.5	ML	10^{-3} to 10^{-6}	Light grey silt

APPENDIX D

UNIFIED SOIL CLASSIFICATION SYSTEM AND CHARACTERISTICS PERTINENT TO SLUDGE LANDFILLS*

Major Divisions		Symbol: Letter	Symbol: Hatching	Symbol: Color	NAME	Potential Frost Action	Drainage Characteristics*	Value for Embankments	Permeability cm per sec	Compaction Characteristics†	Std AASHO Max Unit Dry Weight lb per cu ft‡	Requirements for Seepage Control
COARSE-GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		RED	Well-graded gravels or gravel-sand mixtures, little or no fines	None to very slight	Excellent	Very stable, pervious shells of dikes and dams	$k > 10^{-2}$	Good, tractor, rubber-tired steel-wheeled roller	125-135	Positive cutoff
		GP		RED	Poorly graded gravels or gravel-sand mixtures, little or no fines	None to very slight	Excellent	Reasonably stable, pervious shells of dikes and dams	$k > 10^{-2}$	Good, tractor rubber-tired steel-wheeled roller	115-125	Positive cutoff
		GM		YELLOW	Silty gravels, gravel-sand-silt mixtures	Slight to medium	Fair to poor Poor to practically impervious	Reasonably stable, not particularly suited to shells, but may be used for impervious cores or blankets	$k = 10^{-3}$ to 10^{-6}	Good with close control, rubber-tired, sheepsfoot roller	120-135	Toe trench to none
		GC		YELLOW	Clayey gravels, gravel-sand-clay mixtures	Slight to medium	Poor to practically impervious	Fairly stable, may be used for impervious core	$k = 10^{-6}$ to 10^{-8}	Fair, rubber-tired, sheepsfoot roller	115-130	None
	SAND AND SANDY SOILS	SW		RED	Well-graded sands or gravelly sands little or no fines	None to very slight	Excellent	Very stable, pervious sections slope protection required	$k > 10^{-3}$	Good, tractor	110-130	Upstream blanket and toe drainage or wells
		SP		RED	Poorly graded sands or gravelly sands, little or no fines	None to very slight	Excellent	Reasonably stable may be used in dike section with flat slopes	$k > 10^{-3}$	Good, tractor	100-120	Upstream blanket and toe drainage or wells
		SM		YELLOW	Silty sands, sand-silt mixtures	Slight to high	Fair to poor Poor to practically impervious	Fairly stable not particularly suited to shells, but may be used for impervious cores or dikes	$k = 10^{-3}$ to 10^{-6}	Good, with close control rubber-tired, sheepsfoot roller	110-125	Upstream blanket and toe drainage or wells
		SC		YELLOW	Clayey sands, sand-clay mixtures	Slight to high	Poor to practically impervious	Fairly stable use for impervious core for flood control structures	$k = 10^{-6}$ to 10^{-8}	Fair sheepsfoot roller, rubber-tired	105-125	None
FINE-GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML		GREEN	Inorganic silts and very fine sands rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Medium to very high	Fair to poor	Poor stability may be used for embankments with proper control	$k = 10^{-3}$ to 10^{-6}	Good to poor close control essential, rubber-tired roller sheepsfoot roller	95-120	Toe trench to none
		CL		GREEN	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	Practically impervious	Stable, impervious cores and blankets	$k = 10^{-6}$ to 10^{-8}	Fair to good, sheepsfoot roller, rubber-tired	95-120	None
		OL		GREEN	Organic silts and organic silt-clays of low plasticity	Medium to high	Poor	Not suitable for embankments	$k = 10^{-4}$ to 10^{-6}	Fair to poor, sheepsfoot roller	80-100	None
	SILTS AND CLAYS LL IS GREATER THAN 50	MH		BLUE	Inorganic silts micaceous or diatomaceous fine sandy or silty soils elastic silts	Medium to very high	Fair to poor	Poor stability core of hydraulic dam not desirable in rolled fill construction	$k = 10^{-4}$ to 10^{-6}	Poor to very poor, sheepsfoot roller	70-95	None
		CH		BLUE	Inorganic clays of high plasticity, fat clays	Medium	Practically impervious	Fair stability with flat slopes thin cores, blankets and dike sections	$k = 10^{-6}$ to 10^{-8}	Fair to poor, sheepsfoot roller	75-105	None
		OH		BLUE	Organic clays of medium to high plasticity organic silts	Medium	Practically impervious	Not suitable for embankments	$k = 10^{-6}$ to 10^{-8}	Poor to very poor, sheepsfoot roller	65-100	None
HIGHLY ORGANIC SOILS		Pt		Orange	Peat and other highly organic soils	NOT RECOMMENDED FOR SANITARY LANDFILL CONSTRUCTION						

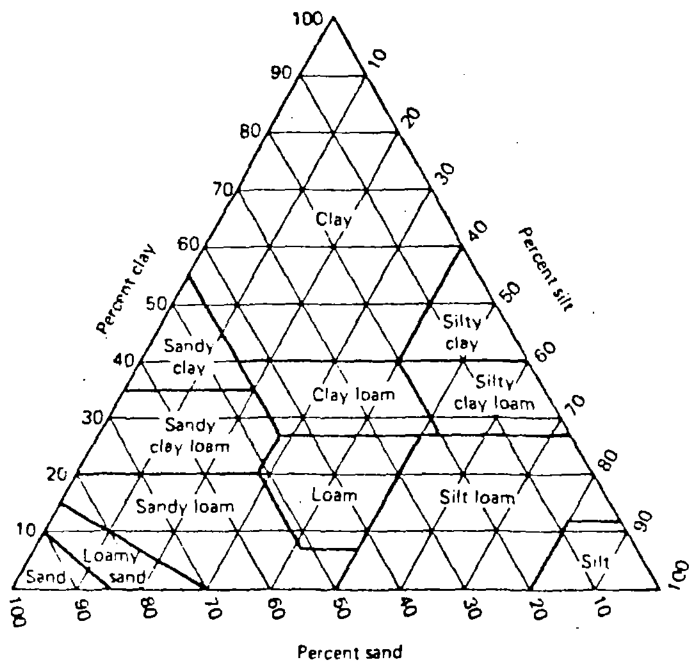
*Values are for guidance only, design should be based on test results

†The equipment listed will usually produce the desired densities after a reasonable number of passes when moisture conditions and thickness of lift are properly controlled.

‡Compacted soil at optimum moisture content for Standard AASHO (Standard Proctor) compactive effort

Note: * Taken from USEPA, SW-705, October 1978.

APPENDIX D



USDA SOIL TEXTURAL CLASSIFICATION DIAGRAM*

Note: * Taken from USEPA, SW-705, October 1978.

APPENDIX E

FIELD PERMEABILITY TEST

APPENDIX E

FIELD PERMEABILITY TEST

MW-1

$K = \frac{D\Delta H}{2H\Delta T}$, where K = average horizontal permeability (feet/day) of earth materials in vicinity of well screen

D = well inside diameter (feet)

H = difference between initial and static water levels (feet)

ΔH = water level decline from beginning to end of test (feet)

ΔT = time from beginning to end of test (days)

$$K = \frac{(0.333)(42)}{2(83)(0.833)}$$

$$= \frac{13.986}{138.278}$$

$$= \underline{0.101 \text{ feet/day}} = 3.56 \times 10^{-5} \text{ centimeters/second}$$

APPENDIX F

GROUNDWATER QUALITY

Technical Memorandum
Union Science & Technology Division
Union Oil Company of California

UNION 76

To:	L. D. Erchull, Chicago	Memo:	ARS 81-343M
From:	G. W. Larson	Date:	July 31, 1981
Department:	Chemical Research	Project:	267-65211
Subject:	COD ANALYSES FOR SAMPLES FROM WELLS 1, 2 AND 6	Supervisor:	L. W. Burdett LWB

cc: Library (2)
Patent
D. J. Christoffersen
J. M. Fraser JMF/LWB
H. D. Haas) Chicago
R. W. Sneeberger) Chicago
W. E. Vreuls) Chicago
J. Walker

Listed below are the results of COD analyses from the resampling of Wells 1, 2 and 6 in connection with the groundwater monitoring system at the Chicago landforming operation. These samples were received on July 15, 1981 analyzed on July 16, 1981 and the results were reported to W. E. Vreuls by telephone on July 17, 1981. Attached are copies of the sample identification sheets which were received with the samples. The originals were signed, dated and returned to W. E. Vreuls certifying that these samples were received intact.

Sample	COD, mg/l
Well LF-1 7/14/81	5
Well LF-2 7/14/81	13
Well LF-6 7/14/81	5

Gary Larson

GWL:tsw
attach.

Union Science & Technology Division
Union Oil Company of California

UNION 76

To:	L. D. Erchull, Chicago	Memo:	ARS 81-247M
From:	G. W. Larson	Date:	June 10, 1981
Department:	Chemical Research	Project:	267-65211
Subject:	ANALYSES OF WELL WATER SAMPLES	Supervisor:	L. W. Burdett

cc: Library (2)
Patent
D. J. Christoffersen
J. M. Fraser
H. D. Haas, Chicago
R. W. Sneeberger, Chicago
W. E. Vreuls, Chicago
J. Walker

As requested in W. E. Vreuls letter to Dr. J. M. Fraser dated May 6, 1981 (LAB 63-81), the samples of well water that were received from the Chicago Refinery on May 7 and 13, 1981 were analyzed for each of the constituents listed in sections III.1. and III.2. of H. D. Haas' letter to Dr. J. M. Fraser dated January 26, 1981 (ENV 17-81). The results of these analyses are compiled in Table 1 along with the analytical technique used to perform the analyses.

Table 2 lists the elapsed time between sampling and analysis for each of the properties which were requested as well as the EPA recommended maximum retention times. Obviously, many of these recommended maximum retention times could not be met especially since many are only 24 hours. However, these data do show diligence on our part in obtaining these results particularly for the tests most sensitive to retention time, cyanide and phenols, which were completed within 3 days of sampling. It should be noted that since shipping regulations prohibit the use of nitric acid, the samples for metals were shipped without preservative. However, they were immediately fixed with the recommended nitric acid upon arrival at the Science and Technology Division.

Also attached are copies of the sample identification sheets which were received with the samples. The originals were signed, dated and returned to W. E. Vreuls certifying that these samples were received intact with the exception of aliquot #7 of the control blank which had the cap broken off. It should be noted that the TOC and TOX samples were not taken from Aliquot #4 as originally indicated on the identification sheets since it was felt that a sample from a glass container would yield better results. Therefore, the TOC was performed on samples from

Aliquot #2 for the reference blank, and well samples 3, 4 and 5 and from Aliquot #7 for the control blank and well samples 1, 2 and 6. For the same reason, TOX samples for the reference blank and well samples 3, 4 and 5 were taken from Aliquot #2. These corrections have been noted on the attached sample identification sheets.

Gary Larson

GWL:tsw
attach.

In Reply Give No
LAB 90-81

UNION

Chicago Refinery
June 23, 1981

Mr. H. D. Haas

LAND FARM WELL WATER ANALYSIS

Below are listed the results of analyses run on water samples taken from the Chicago Refinery land farm monitoring wells.

Sample	Time and Date of Sample	Oil & Grease[1] ppm	pH[2]
Well #1	0755 May 12, 1981	1.4	6.9
Well #2	0710 May 12, 1981	1.1	6.5
Well #3	0815 May 6, 1981	1.5	6.7
Well #4	0755 May 6, 1981	0.7	6.8
Well #5	0730 May 6, 1981	5.6	7.3
Well #6	0630 May 12, 1981	1.2	7.0
Reference Blank[3]	0900 May 6, 1981	<0.1	7.0
Control Blank[4]	0830 May 12, 1981	0.8	6.9

[1] Methods for Chemical Analysis of Water and Wastes

[2] Corning pH Meter Model 130

[3] Deionized water from laboratory at Chicago Refinery

[4] Chicago Refinery potable water from fire station.

W E Vreuls

W. E. Vreuls
Supervisor - Laboratory

FORM ... PRINTED IN U.S.A.

WEV/jah

INSTRUCTIONS FOR COMPLETING WATER ANALYSIS REPORT FORM

NOTE: Bacteriological samples must reach laboratory in time for analysis to be started within 30 hours after collection.

Information requested within heavy lined area (boxes 1 thru 7) must be completed by sample collector or other authorized Water Supply personnel as follows:

1. Mail Report To: Fill in the name and address of the person to whom analysis results are to be sent.

2. Date Collected: Fill in date samples were collected. If this information is not provided, samples will be discarded.

3. Sample Collector: Fill in name of person or persons who collected samples.

4. Sample Purpose: Check appropriate box to indicate the following:
   Routine - regular monthly samples.
   Resample - sample submitted to check unsatisfactory results of previous analysis or to replace samples previously submitted but not analyzed.
   New Construction - sample submitted to verify proper disinfection of new construction. Permit number of new construction is to be filled in.
   Other - samples submitted for any other reason. Reason should be indicated.

5. Contact Person for Unsatisfactory Samples: Fill in name and phone no. of person to be contacted in case analyses indicate contamination.

6. BACTERIOLOGICAL SAMPLES (Glass Bottles): Fill in following information for each sample submitted:
   Bottle Number - Indicate bottle number which corresponds to sampling point. (1, 2, 3 etc.)
   Sampling Point - Indicate point where sample was collected (i.e. well no., intake, plant tap, distribution system address.)
   Sample Type - Indicate sample type by letters R, F, or D as follows:
   - R - Raw sample from well or intake of surface water supply.
   - F - Finished sample taken at water plant after treatment.
   - D - Distribution sample taken at any point in the distribution system.

   Time Collected - Indicate actual time sample was collected. If this information is not provided, samples may be discarded.
   Res Cl - Residual chlorine reading for finished or distribution sample taken at time and point where sample was collected.

7. ROUTINE CHEMICAL SAMPLES (Plastic Bottles): Fill in following for samples submitted:
   Bottle Type "R" or "F" - Fill in R for raw water. Collect all raw samples at the same location. Use one line only for all R samples.
   Indicate F for finished water. Collect all finished samples at the same location. Use one line only for all F samples.
   Sampling Point - Indicate point where sample was collected.

EXPLANATION OF DATA AND SYMBOLS ON WATER ANALYSIS REPORT FORM

8. Sample Amt. - Colonies Read - Amount of sample analyzed and no. of colonies read will be entered in this block.

9. Total Coliforms per 100 ml - A number, G+ or G- will be indicated as follows:
   Number - Indicates actual number of coliform colonies counted or calculated per 100 ml sample. If colonies are confirmed a + (positive) or - (negative) will be used to indicate verification.
   G+ - Indicates excessive bacterial growth which confirms positive for coliform.
   G- - Indicates excessive bacterial growth which confirms negative for coliform.

10. Opinion - Indicated S, Q, or U as follows:
    S - Satisfactory - Indicates no coliform detected.
    Q - Questionable - Indicates coliform of 4 or less or excessive bacterial growth which confirms negative.
    U - Unsatisfactory - Indicates more than 4 coliforms detected or excessive bacterial growth which confirms positive.

11. Laboratory Number: Unique number assigned to each sample by laboratory.

12. Alkalinity and Hardness - Reported in milligrams per liter (mg/l) of calcium carbonate.

13. pH - pH of sample as received in laboratory reported as pH units.

14. Iron - reported in milligrams per liter (mg/l) of iron.

15. Nitrate - reported in milligrams per liter (mg/l) of nitrogen. A reading greater than 10 mg/l may be harmful to infants.

16. To be used by laboratory to report any other chemical analysis required in mg/l unless otherwise specified.

ARRO Laboratories, Inc.

CERTIFICATION NUMBER 17554

Telephone 815 727-5436 312 454-0245
Telex 723421 UAR JOL

mples must reach lab within hours after collection.

Facility No.
County

Date and Time in Laboratory: 5/12/81 12:00PM

Mail Report to:
ne: UNION OIL COMPANY
lress: Chicago Refinery
Office: Lemont State: Illinois Zip Code: 60439

LLECTOR: *Fill in boxed area only. Type or press firmly with point pen. See reverse side for explanations and instructions.*

2. Date Collected: 5/12/81

3. Sample Collector: N.B. Kuna

4. Sample purpose:
- [X] Routine
- [ ] New Construction - Permit No. ____ FY19__
- [ ] Resample
- [ ] Other - ____

5. Contact person for unsatisfactory samples:
Name: N.B. Kuna Phone Number: 312-257-7761

6. Bacteriological Samples (Glass Bottles)

...tle ...ber	Sampling Point	Sample Type	Time Collected	Res. Cl	8. Sample Amt.	Col-onies Read	9. Total Coliform per 100ml (by MF)	10. Opinion	11. Laboratory number
	Control Blank Aliquot #8, Seal #00036		8:30		100	0	0/100	S	63597E
	Well #LF-1 Aliquot #8, Seal #00044		7:55		10	>5000	>5000 *	U	63598E
	Well #LF-2 Aliquot #8, Seal #00052		7:10		10	>5000	>5000 *	U	63599E
	Well #LF-6 Aliquot #8, Seal #00060		6:30		10	380	380 *	U	63600E

7. Routine chemical samples (Plastic Bottles)

...le ...r	Sampling Point	12. Alkalinity P	Total	12. Hardness	13. pH	14. Iron	15. Nitrate	16.

ported by: Gaida Rudzitis Date: 5/18/81

* Confirmed in LST and B.G. Broth

[signature]

WS Notification for Unsatisfactory Results
son Notified: Date: Time:

Date & Time Analysis Started 5/12 12PM

Hours Elapsed ____

NOTE: Sampling bags inadequately sealed and overfilled

Bottles Sent Date:

WATER ANALYSIS REPORT FOR

CERTIFICATION NUMBER 17554

ARRO Laboratories, Inc.

Telephone 815 727-5436 312 454-0245
Telex 723421 UAR JOL

...ples must reach lab within ...hours after collection.

Facility No.
County

Date and Time in Laboratory: 5/6/81 1:00 PM

...ail Report to:
...e: UNION OIL COMPANY
...ess: Chicago Refinery
...Office: Lemont State: Illinois Zip Code: 60439

...LECTOR: *Fill in boxed area only. Type or press firmly with ...point pen. See reverse side for explanations and instructions.*

2. Date Collected. 5/6/81

3. Sample Collector: Union Oil Co.

4. Sample purpose:
☐ Routine ☐ New Construction - Permit No. ____ FY10__
☐ Resample ☒ Other - ____

5. Contact person for unsatisfactory samples:
Name: Mr. Vern Lemke Phone Number: 312-257-7761

6. Bacteriological Samples (Glass Bottles)

...le ...ber	Sampling Point	Sample Type	Time Collected	Res. Cl	8. Sample Amt.	Colonies Read	9. Total Coliform per 100ml (by MF)	10. Opinion	11. Laboratory number
	Well #LF-3 Aliq.7 Seal #00014				5ml	400	2000 *	U	63468E
	Well #LF-4 Aliq.7 Seal #00021				50ml	100	<1**	Q	63469E
	Well LF-5 Aliq.7 Seal #00028				50ml	1000	<1**	Q	63470E
	Reference Blank Aliq 7 Seal # 00007				100ml	0	<1	S	63471E

7. Routine chemical samples (Plastic Bottles)

...le ...F	Sampling Point	12. Alkalinity P	Total	12. Hardness	13. pH	14. Iron	15. Nitrate	16.

...oned by: Joan Anderson Date: 5/14/81

...VS Notification for Unsatisfactory Results
...son Notified: Date: Time:

Date & Time Analysis Started ____
Hours Elapsed ____

* Confirmed
** Excessive bacterial growth confirmed negative for coliforms

____ Bottles Sent Date: ____

Sampling bags inadequately sealed and overfilled

ARS 81-247M

Deionized H2O Potable H2O

TABLE 1*

	Analytical Method	Reference Blank	Control Blank	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6
Alkalinity	Titration (pH 4.5)*	nd(<1)	266	398	298	343	643	430	334
Aluminum	FAE	0.07	0.05	0.06	0.2	0.08	nd(<0.02)	0.05	0.06
Arsenic	SDDC*	0.004	0.009	0.010	0.009	0.015	0.033	0.010	0.009
Barium	FAE	nd(<0.02)	0.05	0.11	0.04	0.05	0.04	0.09	0.09
Bicarbonate	Titration	nd(<1)	325	485	364	419	784	524	407
Boron	Curcumin*	nd(<0.1)	0.6	0.4	0.6	0.6	0.1	0.2	0.5
Bromide	IC	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)
Cadmium	AA*	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)
Calcium	FAE	0.06	62	79	49	74	133	99	64
Carbonate	Titration	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)
Chloride	IC	nd(<1)	26	23	28	30	3	9	28
Chromium (total)	FAE	0.006	0.005	0.004	0.004	0.004	0.004	0.005	0.004
Chromium (VI)	Chealation-Extraction-AA*	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.002)	nd(<0.002)
Chromium (III)	Difference	0.006	0.005	0.004	0.004	0.004	0.004	0.005	0.004
Copper	AA*	0.02	nd(<0.02)	nd(<0.02)	nd(<0.02)	0.02	nd(<0.02)	nd(<0.02)	nd(<0.02)
COD	SM*	nd(<0.5)	nd(<1)	385	73	nd(<0.5)	nd(<0.5)	nd(<0.5)	22
Cyanide	Distillation*	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)	nd(<0.01)
Fluoride	ISE*	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2)	nd(<0.2)
Hardness	SM-Calculation*	nd(<4)	233	425	507	342	732	488	280
Iron	AA*	0.2	0.4	0.4	0.5	0.3	0.4	0.4	0.4
Lead	AA*	nd(<0.05)	nd(<0.05)	0.1	nd(<0.05)	nd(<0.05)	nd(<0.05)	nd(<0.05)	0.07
Magnesium	AA*	nd(<0.5)	18	55	93	38	97	58	29
Manganese	AA*	0.01	0.02	0.2	0.09	0.06	0.05	0.39	0.1
Mercury	CVAA*	nd(<0.0005)	nd(<0.0005)	0.0008	0.0008	nd(<0.0005)	nd(<0.0005)	nd(<0.0005)	nd(<0.0005)
Nickel	FAE	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)
Nitrate	IC	nd(<1)	3	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)	nd(<1)
Phenols	SM*	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.003)	nd(<0.003)
Phosphate	IC	nd(<1)	1	4	5	5	nd(<1)	nd(<1)	4
Potassium	FAE	nd(<0.01)	15	7.8	11	13	3.1	10	11
Selenium	XRF	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5)	nd(<0.5)
Silver	AA*	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)	nd(<0.02)
Sodium	FAE	0.1	72	106	115	72	16	22	84
Specific Conductance	Conductivity Meter*	0.77 µS/cm	709 µS/cm	1095 µS/cm	801 µS/cm	810 µS/cm	1250 µS/cm	960 µS/cm	810 µS/cm
Sulfate	IC	nd(<1)	86	233	106	116	134	122	96
TDS	EPA*	2	486	761	546	567	368	497	540
TOC	FID	4.0	2.0	11.0	8.0	18.5	11.0	15.0	4.0
TOX (as Cl)	M	0.005	0.025	0.060	0.54	0.020	0.015	0.005	0.030
Zinc	AA*	0.03	1.9	0.03	0.1	0.06	0.04	0.03	0.03

\# All results are reported in mg/l except where otherwise indicated.

nd None detected. If present at all, the concentration is less than the indicated amount.

* EPA approved techniques for these analyses.

FAE Flame Atomic emission spectrometry.

SDDC Colorimetric silver diethyldithiocarbamate detection of generated arsine.

IC Ion chromatography. Ion exchange chromatography of anions with conductometric detection.

AA Atomic absorption spectrometry.

SM Method from Standard Methods for the Examination of Water and Wastewater.

ISE Ion selective lanthanum fluoride single crystal electrode.

CVAA Atomic absorption spectrometry with cold vapor generation of mercury.

XRF X-ray fluorescent detection of selenium after concentration by precipitation with sodium diethyldithiocarbamate using nickel as an internal standard.

FID Flame ionization detection of organic carbon after separation of inorganic carbon and oxidation/reduction of organic carbon. Analyses contracted through Certified Testing Laboratories - 2905 E. Century Blvd., South Gate, CA 90280.

M Microcoulometric detection of total organic halogen (reported as the chloride) after concentration of the organic halogens on activated charcoal. Analyses contracted through Environmental Research Laboratory, a division of James M. Montgomery, Consulting Engineers - 555 E. Walnut St., Pasadena, CA 91101.

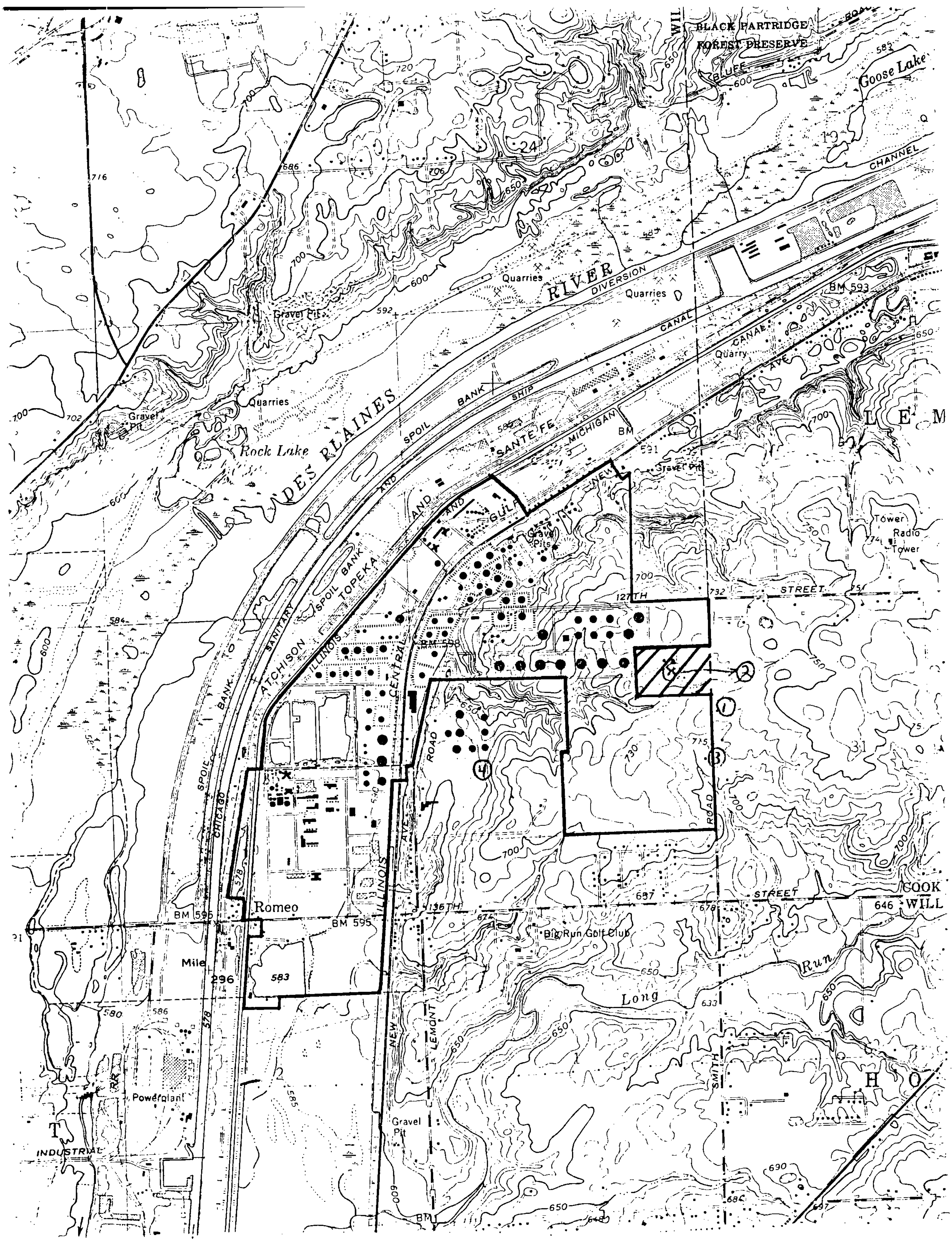
Cr(III) Determined by difference between total chromium and hexavalent chromium.

Hardness Hardness was determined by calculation from the Ca, Mg, Fe, Al, Zn and Mn contents as described in Standard Methods for the Examination of Water and Wastewater.

TABLE 2

Elapsed Time Between Sampling and Analysis, Days

	EPA Recommended	Reference Blank	Control Blank	Well Number 1	2	3	4	5	6
Alkalinity	1	5	8	8	8	5	5	6	7
Aluminum	180	20	14	14	14	20	20	20	14
Arsenic	1	7	3	3	3	7	7	7	3
Barium	180	12	6	6	6	12	12	12	6
Bicarbonate	-	5	8	8	8	5	5	6	7
Boron	180	13	7	7	7	13	13	13	7
Bromide	1	5	3	3	3	5	5	5	3
Cadmium	180	8	13	13	13	8	8	8	13
Calcium	180	9	8	8	9	9	9	9	8
Carbonate	-	5	8	8	8	5	5	6	7
Chloride	7	5	3	3	3	5	5	5	3
Chromium (total)	180	12	6	6	6	12	12	12	6
Chromium (VI)	180	7	6	6	6	7	7	7	6
Copper	180	8	9	9	9	8	8	8	9
COD	7	7	3	3	6	7	7	7	3
Cyanide	1	3	3	3	3	3	3	3	3
Fluoride	7	12	6	6	6	12	12	12	6
Iron	180	15	9	9	9	15	15	15	9
Lead	180	9	13	13	13	9	9	9	13
Magnesium	180	20	8	8	8	20	20	20	8
Manganese	180	9	13	13	13	9	9	9	3
Mercury	38	7	21	21	21	7	7	7	21
Nickel	180	15	9	9	9	15	15	15	9
Nitrate	1	5	3	3	3	5	5	5	3
Phenols	1	3	3	3	3	3	3	3	3
Phosphate	1	5	3	3	3	5	5	5	3
Potassium	180	9	8	8	8	9	9	9	8
Selenium	180	20	14	14	14	20	20	20	14
Silver	180	9	8	8	8	9	9	9	8
Sodium	180	9	9	9	9	9	9	9	9
Specific Conductance	1	8	6	6	6	8	8	8	6
Sulfate	7	5	3	3	3	5	5	5	3
TDS	7	14	9	9	9	14	14	14	9
TOC	1	7	17	17	17	7	7	7	17
TOX	-	8	8	8	8	8	8	8	8
Zinc	180	9	9	9	9	9	9	9	9



BLACK PARTRIDGE
FOREST PRESERVE
Goose Lake
BLUFF
CHANNEL
DIVERSION
RIVER
DES PLAINES
Quarries
Quarries
Quarries
Gravel Pit
Gravel Pit
Rock Lake
SHIP
CANAL
CANAL
SPOIL BANK
SPOIL BANK
SPOIL
BANK
SPOIL
SANTE FE
MICHIGAN
ATCHISON
TOPEKA
AND
AND
AND
GULF
ILLINOIS
CENTRAL
ILLINOIS
CHICAGO
SANITARY
BANK
TO
Quarry
AVE
Gravel Pit
Gravel Pits
Tower
Radio
Tower
L E M
127TH
STREET
NEW
ROAD
LEMONT
ROAD
NEW
AVE
SMITH
ROAD
136TH
STREET
COOK
WILL
Romeo
BM 595
BM 595
BM 593
Mile
296
Big Run Golf Club
Long
Run
H O
Powerplant
RR
Gravel
Pit
T
INDUSTRIAL